

UNCLASSIFIED

AD NUMBER

ADB000464

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; SEP 1974. Other requests shall be referred to Naval Surface Weapons Center, Dahlgren Laboratory, Dahlgren, VA 22448.

AUTHORITY

usnswc ltr, 11 sep 1975

THIS PAGE IS UNCLASSIFIED

THIS REPORT HAS BEEN DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOD DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE,
DISTRIBUTION UNLIMITED.

September 1974

AD B000464

TEMPERATURE AND PRESSURE PROFILES OBTAINED DURING BURN OF A SIDEWINDER MARK 17 MOD 5 MOTOR IN A 15,300 CUBIC-FOOT MAGAZINE

Frank J. Hanzel

Charles L. Berkey

Richard E. Miller, Jr.



U.S. NAVAL WEAPONS LABORATORY
DAHLGREN, VIRGINIA



NAVAL SURFACE WEAPONS CENTER
DAHLGREN LABORATORY
Dahlgren, Virginia
22448

C. J. Rorie, Capt., USN
OIC, and Assistant Commander

C. W. Bernard
Deputy Technical Director

DL Technical Report No. TR-3139
September 1974

TEMPERATURE AND PRESSURE PROFILES OBTAINED
DURING BURN OF A SIDEWINDER MK 17 MOD 5 MOTOR IN A
15,300 CUBIC-FOOT MAGAZINE

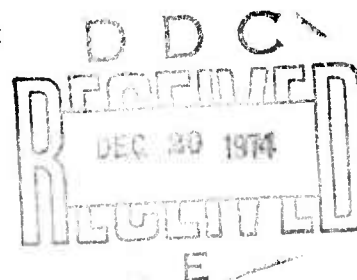
by

Frank J. Hanzel
Charles L. Berkey

Engineering Department

Richard E. Miller, Jr.

Test and Evaluation Department



Distribution limited to U. S. Government agencies only; Test and Evaluation;
September 1974. Other requests for this document must be referred to Commander,
Naval Surface Weapons Center, Dahlgren Laboratory, Dahlgren, Virginia 22448.

ABSTRACT

SIDEWINDER MK 17 MOD 5 motors were ignited in two tests in an instrumented, 15,300 cubic-foot missile magazine under conditions which would simulate accidental ignitions of this motor under shipboard service conditions. The results established a detailed temperature and pressure profile in the magazine, and the thermal characteristics of inert, instrumented ZUNI motors located in the magazine.

Temperatures and pressures within the magazine reached peaks of 570°F and 5.1 psi, respectively. External and internal temperatures for the instrumented ZUNI motors peaked at 175°F and 100°F, respectively, which would not have caused cook-off had the motors been "live".

Environmental conditions in the magazine were not as severe as expected.

CONTENTS

| | Page |
|---|------|
| FOREWORD | i |
| ABSTRACT | ii |
| I. INTRODUCTION | 1 |
| II. APPROACH | 3 |
| III. TEST PROCEDURES | 4 |
| A. Test No. 1 | 4 |
| B. Test No. 2 | 5 |
| IV. TEST RESULTS | 8 |
| A. Test No. 1 | 8 |
| B. Test No. 2 | 9 |
| V. DISCUSSION AND RECOMMENDATIONS | 10 |
| REFERENCES | 12 |
| APPENDICES | |
| A. Test Magazine Configuration and Instrumentation for Tests No. 1 and No. 2 | |
| B. Test Data Obtained During Test No. 1 | |
| C. Gas Analyses of Magazine Air Samples | |
| D. Photographs of Magazine Instrumentation and Ordnance Configuration | |
| E. Test Data Obtained During Test No. 2 | |
| F. Distribution | |

I. INTRODUCTION

The Navy's Improved Rearming Rates Program/Assembled Air Launched Weapons (IRRP/AALW) concept has resulted in major changes to weapons systems logistic stowage. This concept provides for missiles to be brought aboard and stowed in aircraft carrier deep stowage magazines in their respective containers. A detailed description of the IRRP/AALW concept is presented in Reference (1).

Since the containers used with the IRRP/AALW concept may delay AALW systems cook-off in deep stowage magazines, Reference (2) assigned NWL the task of obtaining data during a motor burning in a magazine to ascertain if the containers delay cook-off of AALW systems. Under this task, a series of seven tests were conducted by NWL in an instrumented magazine which simulated a CVA deep stowage magazine. These tests were conducted to:

- (1) Provide thermal information to determine the cook-off parameters of AALW systems;
- (2) Reevaluate the need for a wet (as opposed to the lighter weight, less expensive, less complicated dry) sprinkler system in a deep stowage missile magazine;
- (3) Assist in the design of more effective damage control equipment; and
- (4) Provide thermal information to assist in evaluation of thermal protection systems designed for explosive ordnance.

Because data were not documented in past magazine missile motor tests and could not be referenced when needed at a later date, it is the intent of this, and subsequent reports, to document the vast amount of data obtained during the seven tests in this series.

In the first two tests, SIDEWINDER MK 17 MOD 5 motors, secured on a static thrust stand, were fired to obtain detailed temperature and pressure profiles of the simulated magazine, plus the thermal characteristics of inert, instrumented ZUNI motors located in the magazine. These data were used to:

- (1) Determine the size of the active motor to be used in subsequent tests; and
- (2) Determine optimum location of inert, bare, and containerized AALW systems in the magazine for subsequent tests.

Two follow-on NWL Technical Reports (TR's) will contain magazine test data obtained during each of the subsequent five tests in this series. These reports will include data relative to the effects of:

- (1) Using a super-fast activated sprinkler system;
- (2) Deflagration of a missile motor;
- (3) Massive venting of the magazine;
- (4) Using the wet sprinkler system after motor burn; and
- (5) Using a dry sprinkler system after motor burn.

A fourth TR will include an analysis of the collated data obtained during this test program with respect to the need for a wet-type magazine sprinkler system in IRRP/AALW magazines.

II. APPROACH

Because of the high cost of hardware, materials, labor, etc., necessary to conduct magazine tests, a preliminary study was made prior to conducting any tests to:

- (1) Determine if some of the tests foreseeable could be combined or eliminated;
and
- (2) Insure that test sequence, instrumentation, and use of correct explosive ordnance would provide the necessary data.

The test plan resulting from this study was reported by Reference 3, and served as the basis for the two tests reported.

III. TEST PROCEDURES

A. Test No. 1

1. Motor: SIDEWINDER MK 17 MOD 5

(a) In Test No. 1, a SIDEWINDER MK 17 MOD 5 motor was electrically ignited. The test was conducted on 24 July 1973. Ambient temperature was 76°F. Prior to firing, the motor was X-rayed to insure that no cracks or other irregularities were present that would preclude a normal motor burn. The motor was provided with a pressure tap so that chamber pressure could be measured during burning.

2. Magazine Configuration

(a) An NWL missile magazine was modified to simulate a large CVA-type magazine (of the AALW concept). The magazine had a volume of 15,300 cu. ft.

(b) The static thrust stand was secured on the centerline of the test magazine.

(c) The magazine was equipped with a blow-out patch (15 inches in diameter) set to release at 15 psig.

(d) No sprinkler system was used during this test.

3. Instrumentation

(a) Eighty-eight Chromel-Alumel thermocouples (illustrated in Figure 1 of Appendix A) and four strain-gage type pressure transducers were located at selected positions in the magazine (as shown in Figure 2 of Appendix A) to measure free-air temperature and pressure rise in the magazine. Eight of these thermocouples (identified as /s in Figure 2 of Appendix A) were installed with a stainless steel sleeve, (as shown in Figure 3 of Appendix A) to shield the thermocouple from radiant energy during the motor burn. A detailed sketch, (Figure 4 of Appendix A) shows the thermocouple array installation for the test.

(b) Chamber pressure was measured on the active motor during motor burn.

(c) A break-wire was installed on the blow-out patch to determine time of release, if it should occur.

(d) Close of firing key (CFK) and 10KC timing was provided for time correlation.

(e) High-speed camera coverage of the magazine blow-out patch during the test was provided.

(f) Black and white photographs were taken of the test setup, before and after the test.

(g) Gas samples from the test magazine were taken to determine the amount of afterburning resulting from motor exhaust gases. Four samples (2 each) were taken near pressure transducers Nos. 1 and 4. (See Figure 2, Appendix A). These samples were drawn from 1/4-inch-diameter tubes inserted one foot into the magazine, one foot below the overhead, and one foot above the deck. The gas samples were drawn approximately five minutes after motor burnout.

(h) A micro-switch was installed on each of the two Sylphon detectors to measure the melt time of the metal slug. The Sylphon detectors were located on the ceiling of the magazine (as shown in Figure 2 of Appendix A).

4. General

(a) Figure 5 of Appendix A is a block diagram of the Instrumentation Recording System used during Test No. 1.

(b) Figure 6 of Appendix A is a block diagram of the Pressure Data Reduction System used during Test No. 1.

B. Test No. 2

1. Motor: SIDEWINDER MK 17 MOD 5

(a) Motor preparation and ignition were the same as for Test No. 1. This test was conducted on 7 August 1973. Ambient temperature was 76°F.

2. Magazine Configuration

(a) The magazine configuration was the same as for Test No. 1 except that four instrumented, inert-loaded (Filler E) ZUNI motors were located on (approximately) the 400°F isotherm of the active motor exhaust stream as shown in Figure 7 of Appendix A. This configuration gave an indication of the temperatures developed in motors located in the exhaust of a burning motor. Also, this configuration was used to determine the effects of short-term exhaust impingement which would occur if the burning motor could move.

3. Instrumentation

(a) The magazine instrumentation for Test No. 2 (shown in Figure 8 of Appendix A) was the same as for Test No. 1 except that the number of free-air temperature channels was reduced from 88 to 72. These sixteen thermocouples were used to instrument the four ZUNI motors shown schematically in Figure 7 of Appendix A. The exterior ZUNI thermocouples were peened to the motor surface. The interior ZUNI thermocouples were mechanically pressed to bear on the inner wall surface of the motor before filling the motor case with Filler E.

(b) Chamber pressure was measured on the active motor during motor burn.

(c) A break-wire was installed on the blow-out patch to determine time of release, if it should occur.

(d) Close of firing key (CFK) and 10KC timing was provided for time correlation.

(e) Photographie coverage of the magazine layout was provided.

(f) Gas samples from the test magazine were taken to determine the amount of afterburning resulting from motor exhaust gases. Four samples (2 each, same as for Test No. 1) were taken near pressure transducers Nos. 1 and 4 (see Figure 2 Appendix A).

(g) A micro-switch was mounted on each of the two Sylphon detectors to measure the melt time of the metal slug. The Sylphon detectors were located on the ceiling of the magazine at the same location as in Test No. 1 (as shown in Figure 2 of Appendix A).

(h) Microswitches were provided on the pneumatic release pilot (PRP) valve to indicate time of valve function.

4. General

(a) The Instrumentation Recording System and Pressure Data Reduction System techniques used in Test No. 2 were the same as those used in Test No. 1.

IV. TEST RESULTS

The detailed temperature/time, pressure/time, and related data, including photographs obtained during Tests Nos. 1 and 2 are presented in Appendices B through E. The temperature curves 8-x and 8-y shown in Figure 13 of Appendix B, 17-z in Figure 22, and 20-w in Figure 25 of Appendix E, recorded during Tests Nos. 1 and 2, respectively, show an erratic drop followed by a rise in the temperature pattern. These unusual temperature patterns may be due (in part) to erratic behavior of and/or failure of the individual thermocouples. The results of these tests are given below.

A. Test No. 1

(1) Figure 1 of Appendix B indicates that normal motor chamber pressure and motor burn occurred.

(2) The pressure profile measured inside the test magazine ranged between 3.8 and 5.4 psig, as shown in Figures 2 through 5 of Appendix B.

(3) A temperature profile of the magazine (interior) is shown in Figures 6 through 27 of Appendix B.

(4) The magazine did not vent.

(5) Percentages of gases present in the test magazine after the motor burn are given in Appendix C.

(6) The metal slug in the Sylphon detector failed to melt.

(7) Figure 1 of Appendix D is a photograph of the magazine instrumentation and ordnance configuration.

(8) Figure 2 of Appendix D is a photograph of the active SIDEWINDER MK 17 MOD 5 motor mounted on the thrust stand.

(9) Figure 3 of Appendix D is a photograph of the Sylphon detector/microswitch installation.

B. Test No. 2

(1) Figure 1 of Appendix E indicates that a normal motor burn with normal chamber pressure occurred.

(2) The pressure profile in the test magazine ranged between 3.8 and 5.4 psig as shown in Figures 2 through 5 of Appendix E. Pressure gauge P1 failed during this test.

(3) A detailed temperature profile of the test magazine (interior) is shown in Figures 6 through 27 of Appendix E.

(4) Exterior and interior temperature measurements on the four inert, instrumented ZUNI motors located in the active motor exhaust plume are shown in Figures 28 through 31 of Appendix E.

(5) The magazine vented 1.7 seconds after motor ignition. Venting occurred through a 1.23-sq-ft opening. Failure of the blow-out patch shear-bolt (notched to release at 15 psig) resulted in premature magazine venting. Figure 4 of Appendix D (an electron microscope photograph of the recovered shear-bolt) shows the oxides (dark areas) formed in the stress fracture in the shear-bolt. The stress fracture occurred during the first test and the oxides were formed during the time interval between Test No. 1 and Test No. 2.

(6) Exhaust gases present in the magazine after the motor burn are shown in Appendix C.

(7) The metal slug in the Sylphon detector failed to melt.

(8) PRP valve activation occurred due to the temperature rate of rise at 2.44 seconds after CFK.

(9) Figures 5 through 8 of Appendix D are photographs of the magazine instrumentation array and ordnance (active SIDEWINDER MK 17 MOD 5 and inert, instrumented ZUNI motors) configuration.

V. DISCUSSION AND RECOMMENDATIONS

1. It is evident from the magazine thermal and pressure data (shown in Figures 6 through 27 in Appendices B, and E) obtained during burn of a SIDEWINDER MK 17 MOD 5 rocket motor in Tests Nos. 1 and 2, that the magazine thermal environment was not as severe as expected or desired. Because of these low temperature and pressure profiles, a SPARROW MK 38 motor was used as the active motor in follow-on tests.
2. Temperature data obtained for the inert, instrumented ZUNI motors (shown in Figures 28 through 31 of Appendix E) located in the 400°F isotherm of the exhaust plume of the active motor also indicate that the temperature was not severe enough to have caused cook-off had the motors been "live". However, ordnance cook-off may occur if there is direct long-term impingement of exhaust gases from an ignited motor.
3. In future tests, a 20" X 20" steel baffle will be mounted in front of the blow-out patch to prevent the dynamic pressure of the active motor exhaust from impinging on the blow-out patch.
4. The temperature and pressure profile data of the test magazine obtained during Tests Nos. 1 and 2 will be used to determine optimum location of inert, instrumented, bare, and containerized AALW systems in future tests.
5. Gas sampling techniques used in Tests Nos. 1 and 2 failed to provide the data needed to determine the amount of afterburning that occurred in the magazine. Comparison of the reduction in O_2 , H_2 , and CO gases (reported in Appendix C) indicates that significant afterburning occurred. However, the low percentage of CO_2 indicates that very little afterburning occurred. This inconsistency may be due to uncontrolled gas leakage that occurred around the test magazine door and/or random (rather than continuous) gas sampling. Due to this inconsistency, the gas sampling data proved inconclusive.
6. Thermal and pressure data obtained during the magazine tests described in this report will be collated with, and additional analyses made in conjunction with test data obtained from the five subsequent tests to:
 - (1) Determine the cook-off parameters of AALW systems;
 - (2) Reevaluate the relative effectiveness of the wet vs. dry sprinkler system as damage control mechanisms in preventing chain reaction of AALW systems in deep stowage aircraft carrier magazines;

- (3) Assist in the design of more effective damage control equipment; and
- (4) Provide thermal information to assist in evaluation of thermal protection systems designed for explosive ordnance.

REFERENCES

1. NAVAIR 11-120-27, Guidance Pamphlet, *Assembled Air Launched Weapons Implementation, Improved Rearming Rates Project*, 1 June 1969.
2. NAVSHIP Project S4643, Task 15925.
3. NWL ltr EST:FJH:ddw 8000 8 March 1973.

APPENDIX A

**TEST MAGAZINE CONFIGURATION AND INSTRUMENTATION FOR
TESTS NO. 1 AND NO. 2**

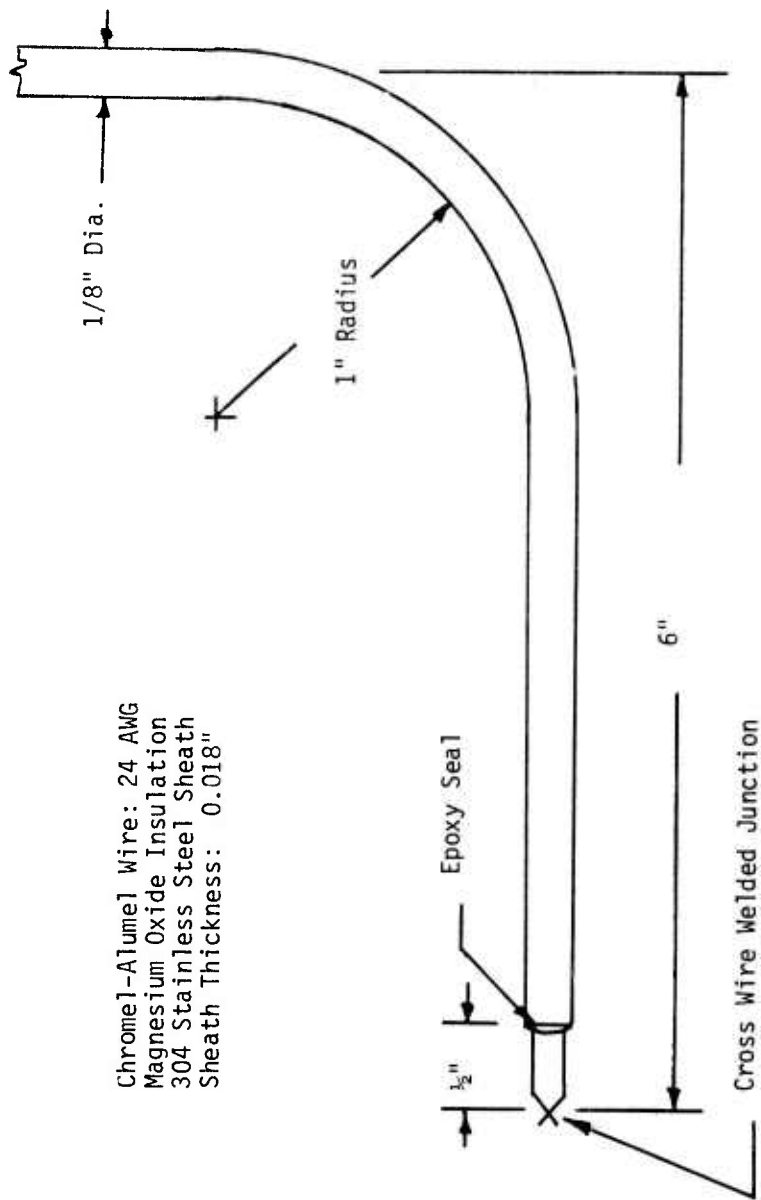


FIGURE A-1
 Thermocouple Detail

(A) * 13' FOR SIDERINDER MOTOR MK17 MOD 5

○ DENOTES PRESSURE TRANSDUCER
△ DENOTES THERMOCOUPLE
◻ DENOTES SYLPHON DETECTOR

Magazine Instrumentation Configuration

- DENOTES PRESSURE TRANSDUCER
△ DENOTES THERMOCOUPLE
○ DENOTES SYLPHON DETECTOR

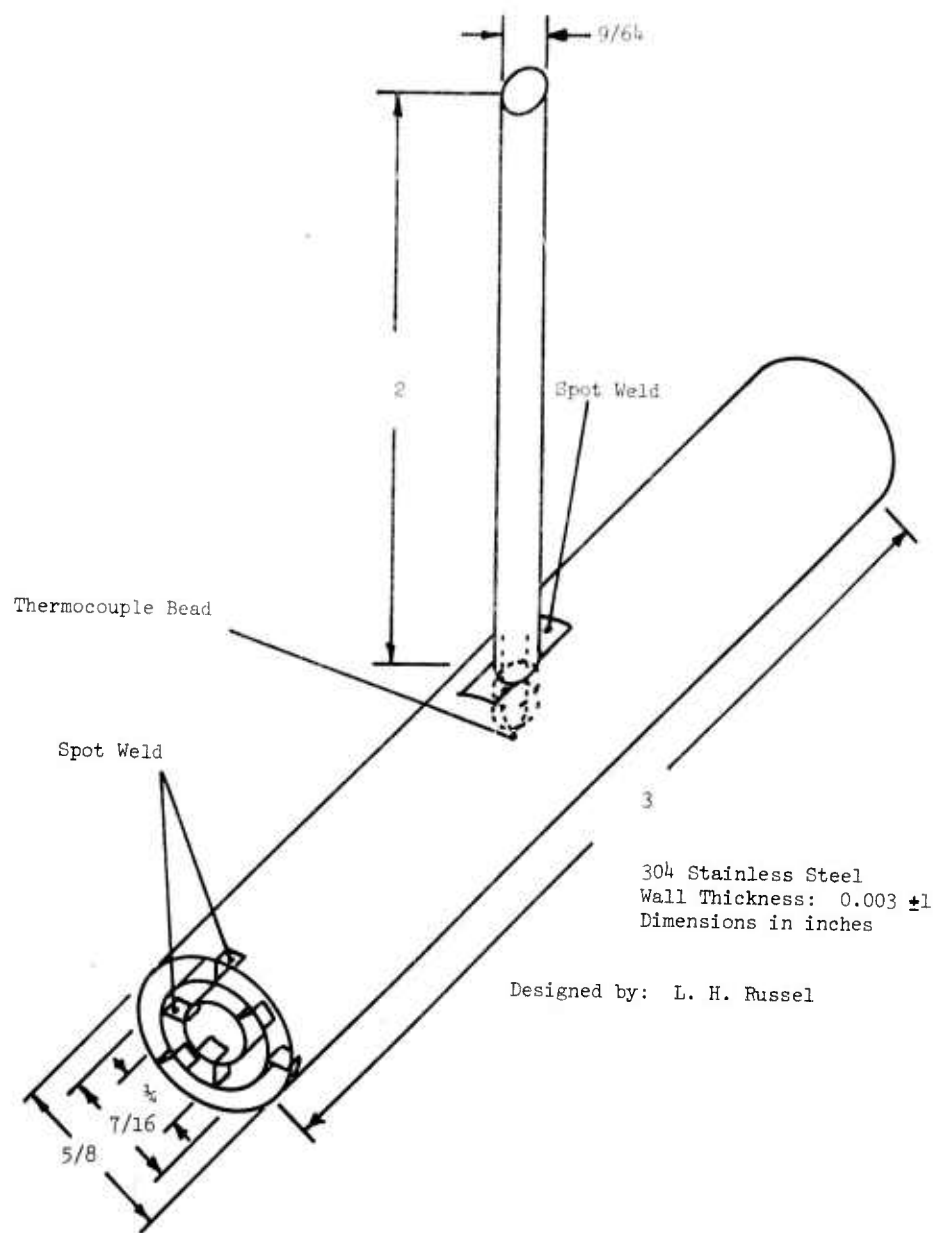


FIGURE A-3
Thermocouple Shield

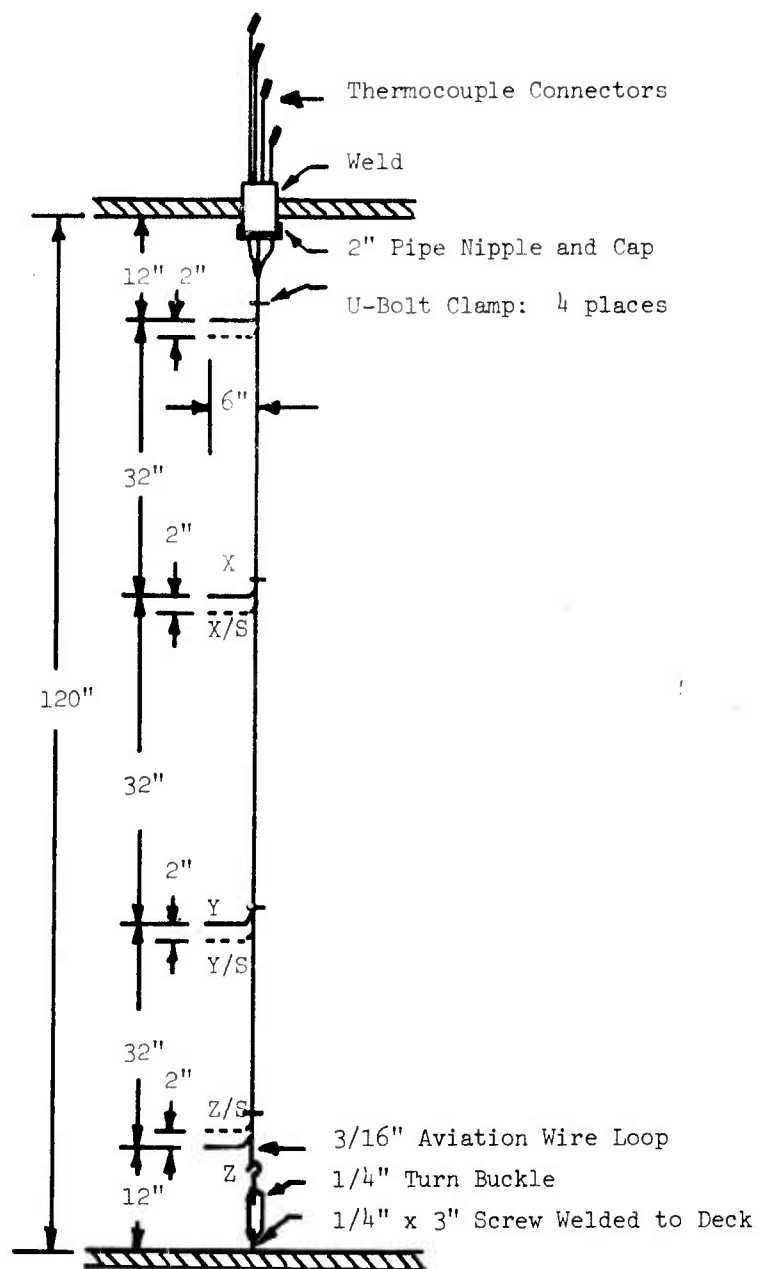


FIGURE A-4
Thermocouple Array

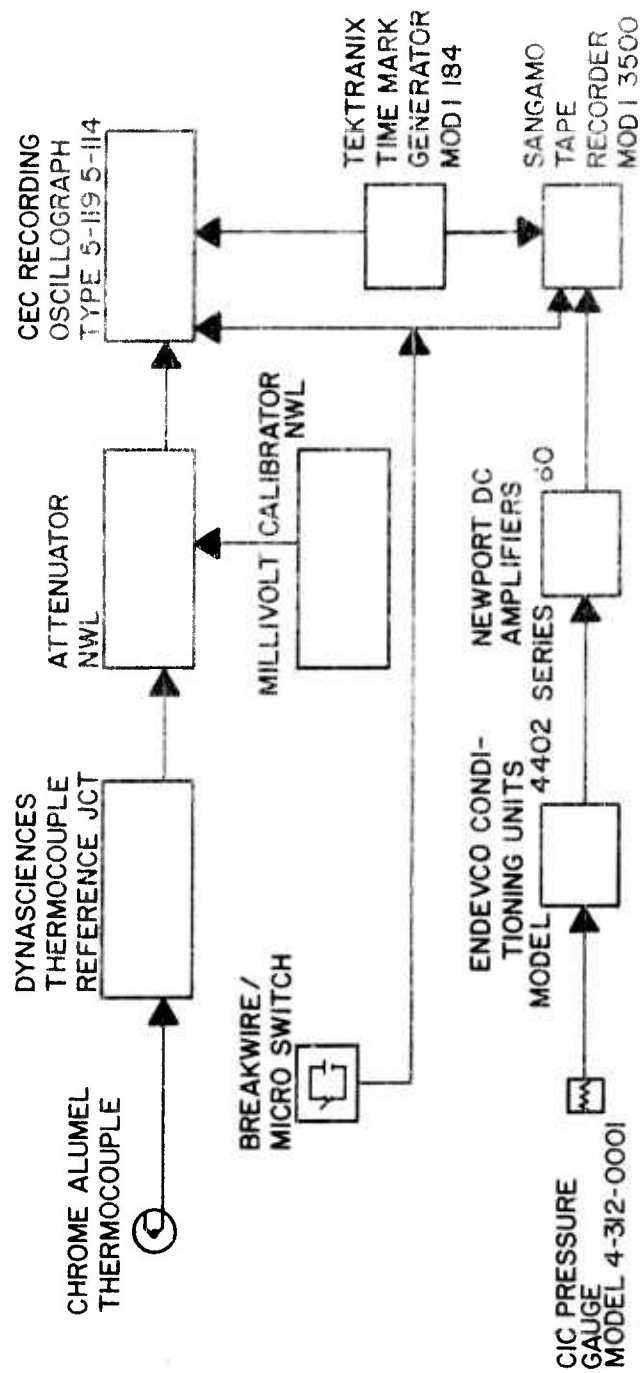


FIGURE A-5
Instrumentation Recording System

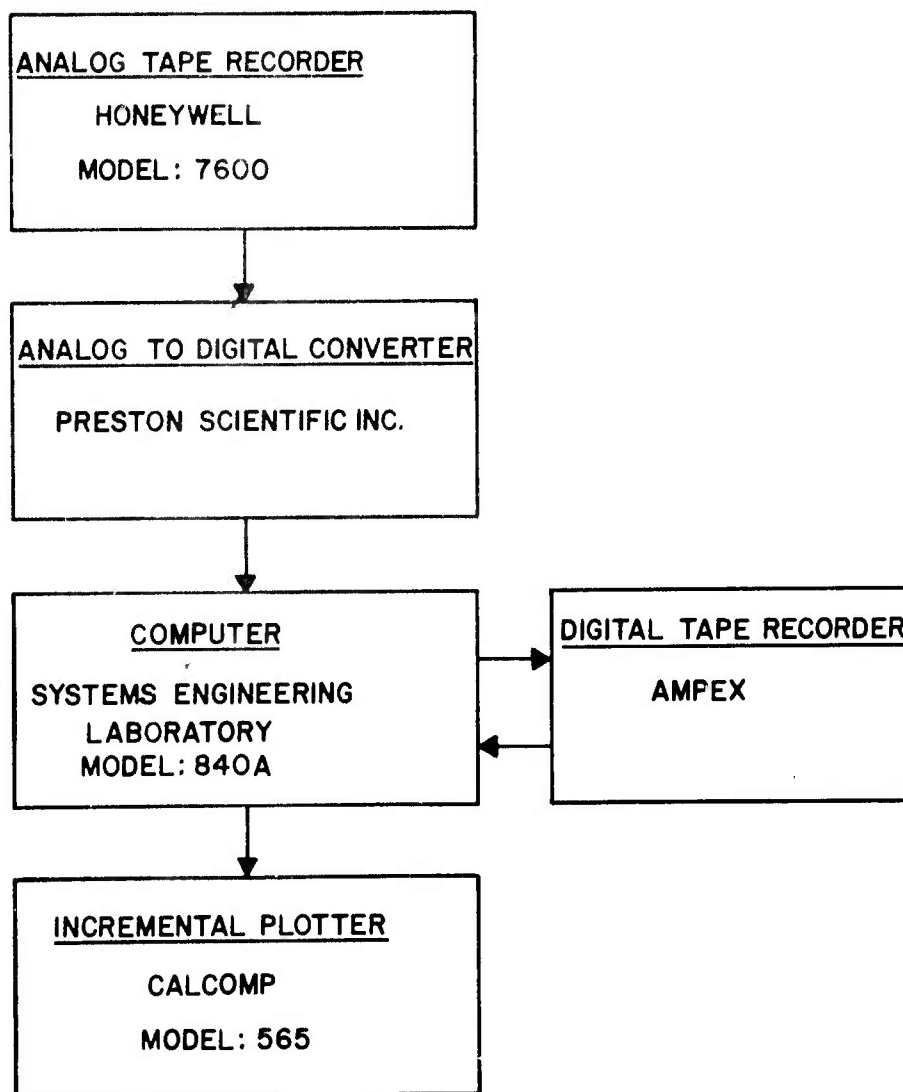


FIGURE A-6
Pressure Data Reduction System

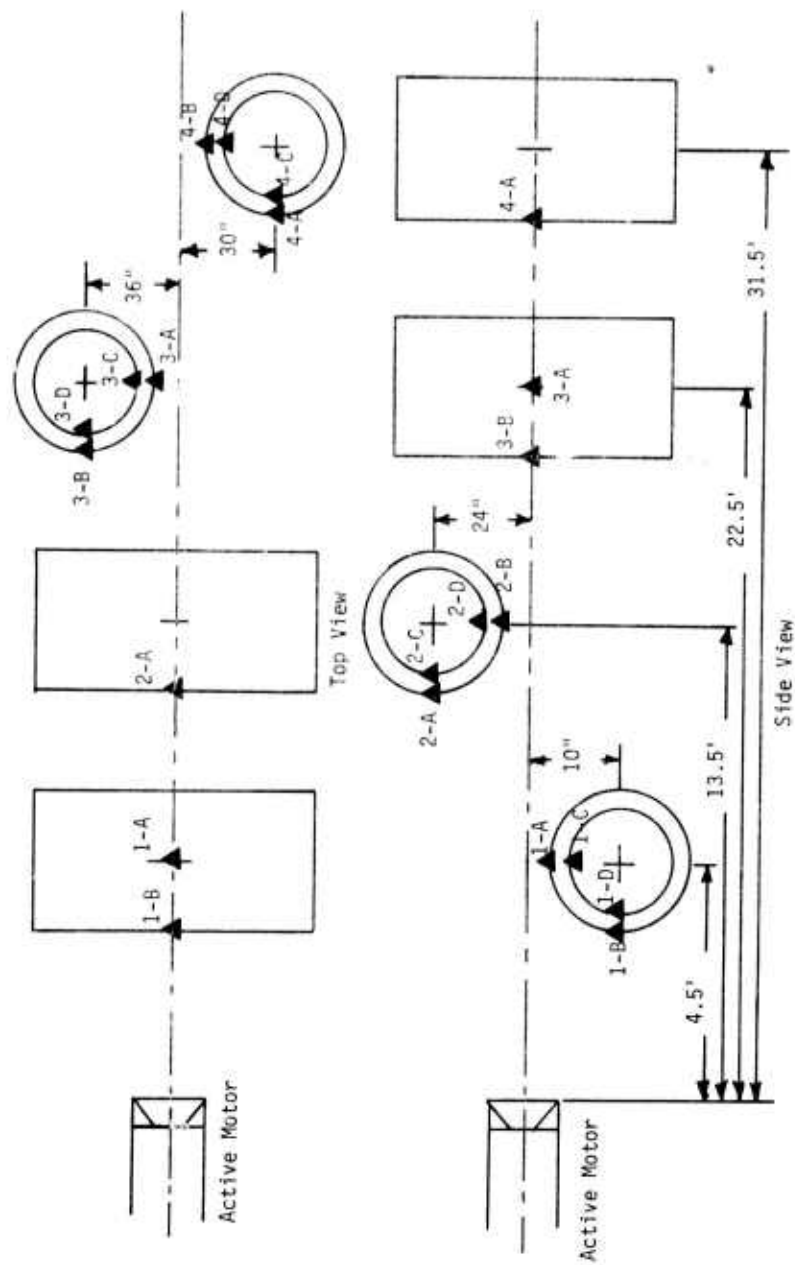


FIGURE A-7
ZUNI Motors in Exhaust Plume

(A) 13' FOR SIDEWINDER MOTOR MK17 MOD 5

○ DENOTES PRESSURE TRANSDUCER
△ DENOTES THERMOCOUPLE
□ DENOTES SYLPHON DETECTOR

FIGURE A-8
Magazine Instrumentation Configuration

APPENDIX B

TEST DATA OBTAINED DURING TEST NO. 1

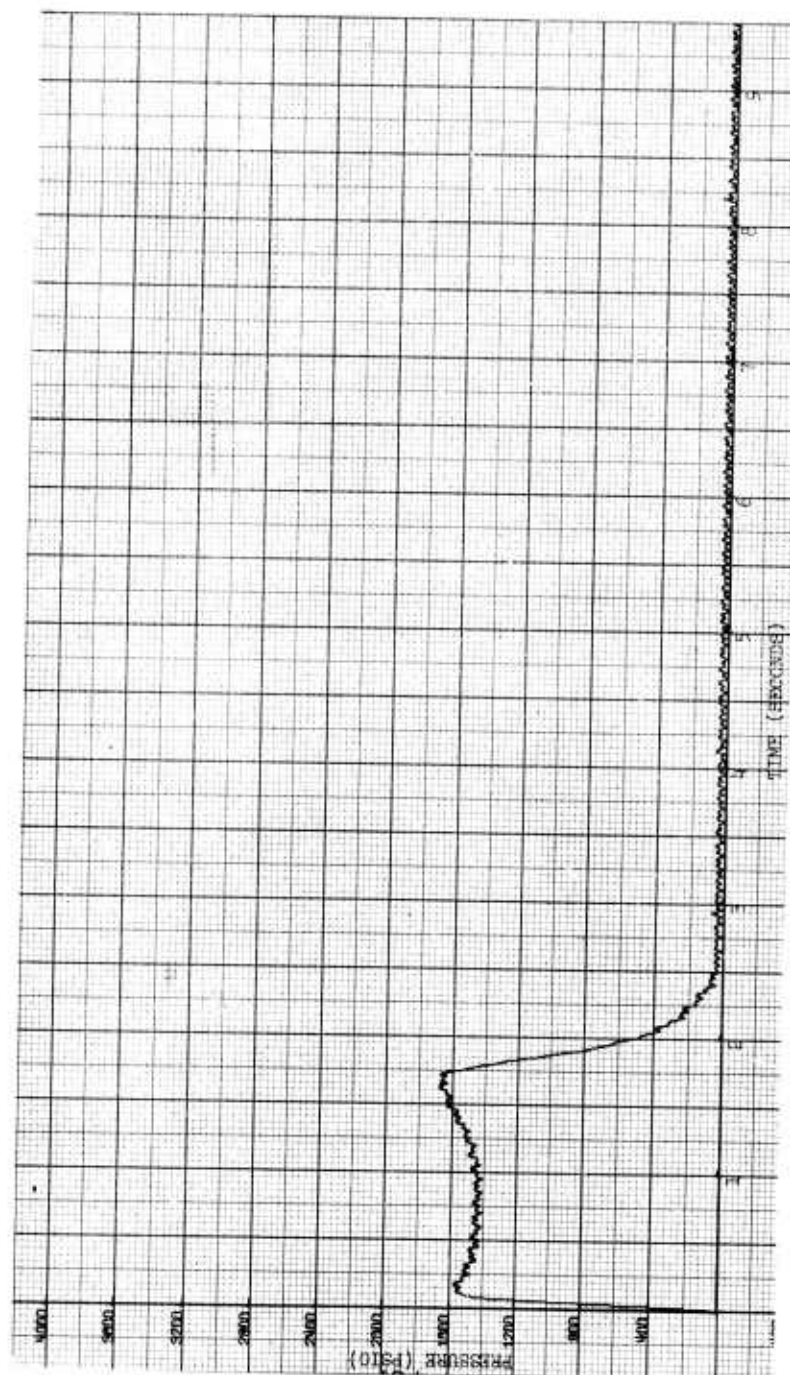


FIGURE B-1
SIDEWINDER MK 17 MOD 5 Motor Pressure
Test No. 1

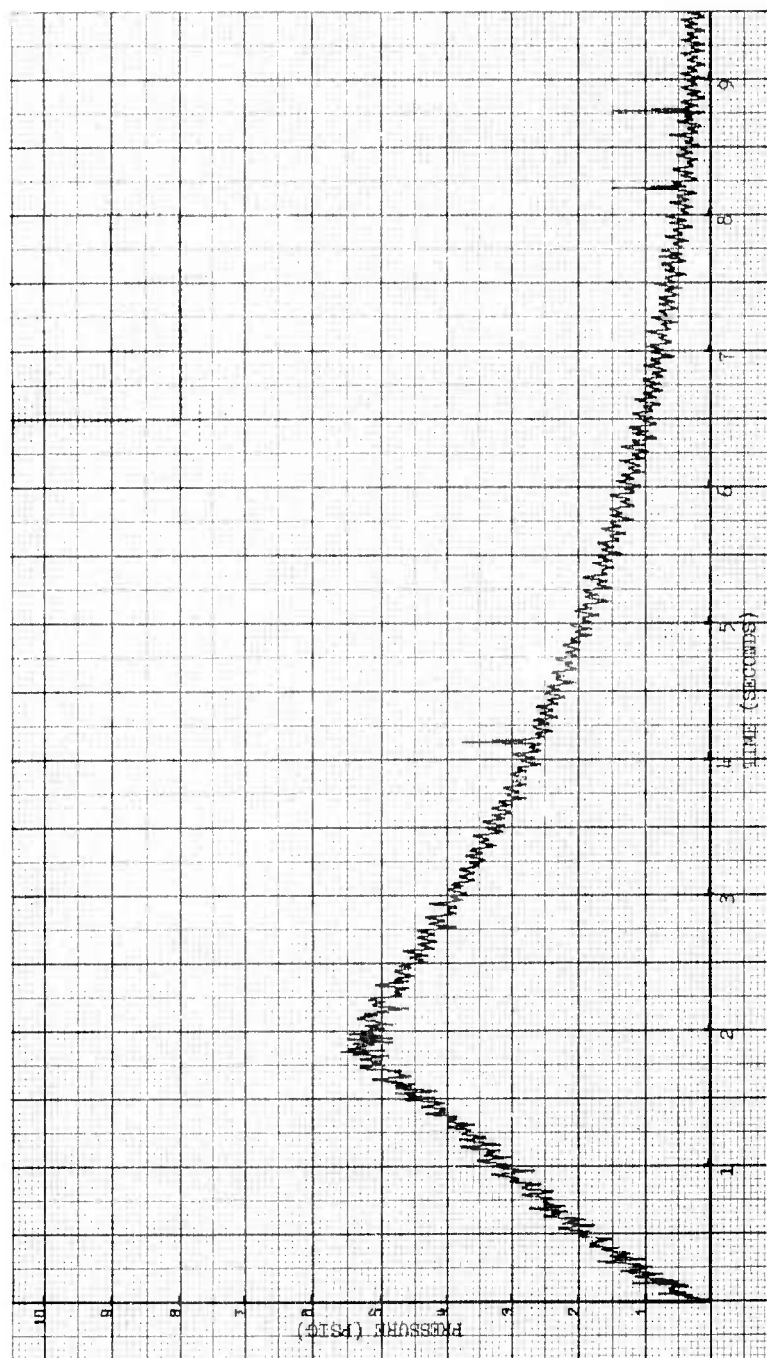


FIGURE B-2

Pressure Transducer No. 1
Test No. 1

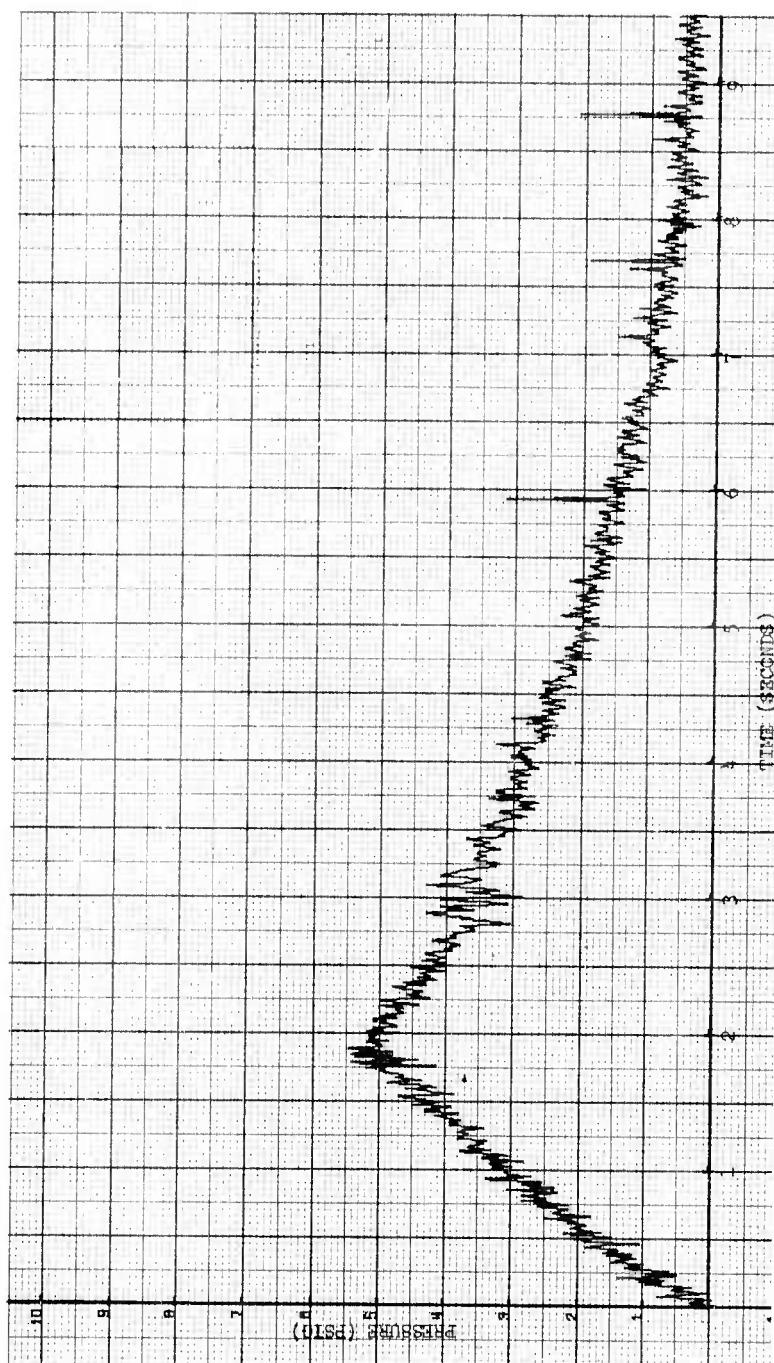


FIGURE B-3
Pressure Transducer No. 2
Test No. 1

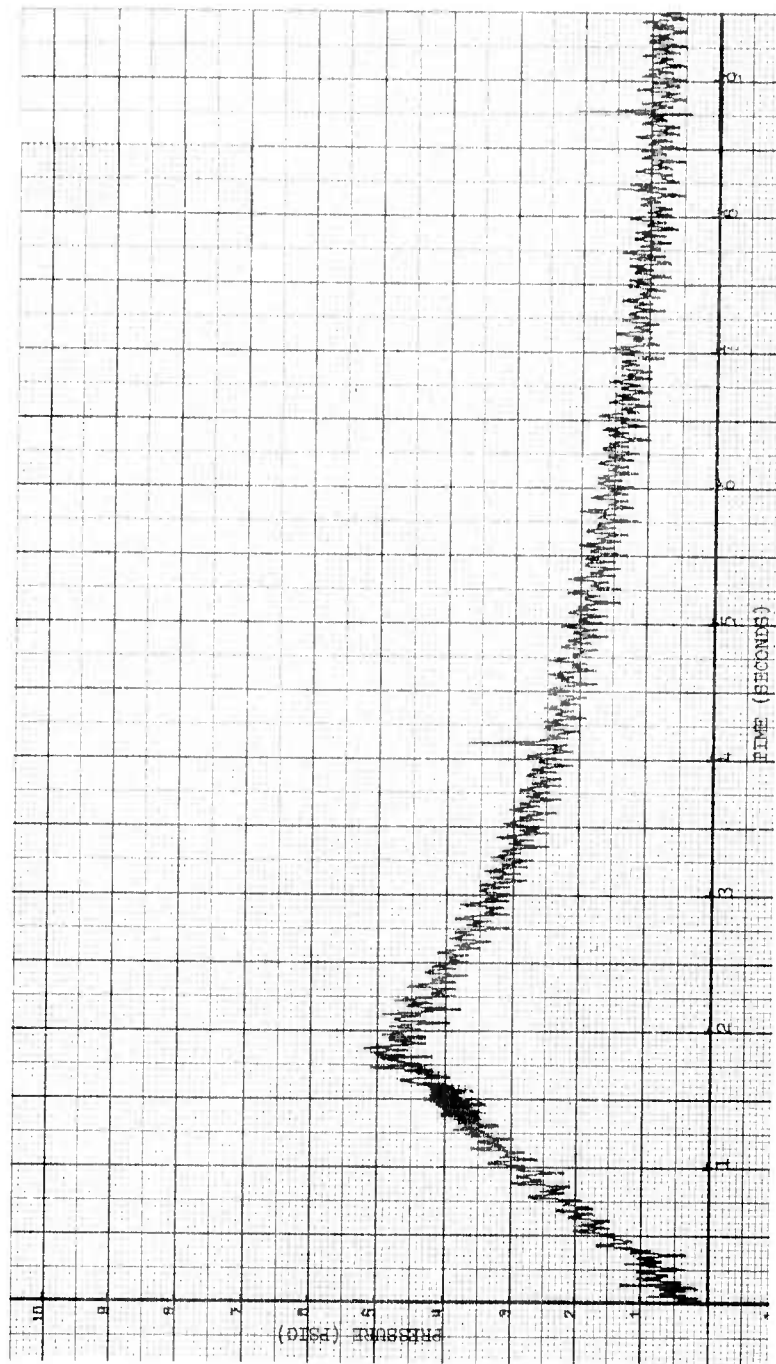


FIGURE B-4
Pressure Transducer No. 3
Test No. 1

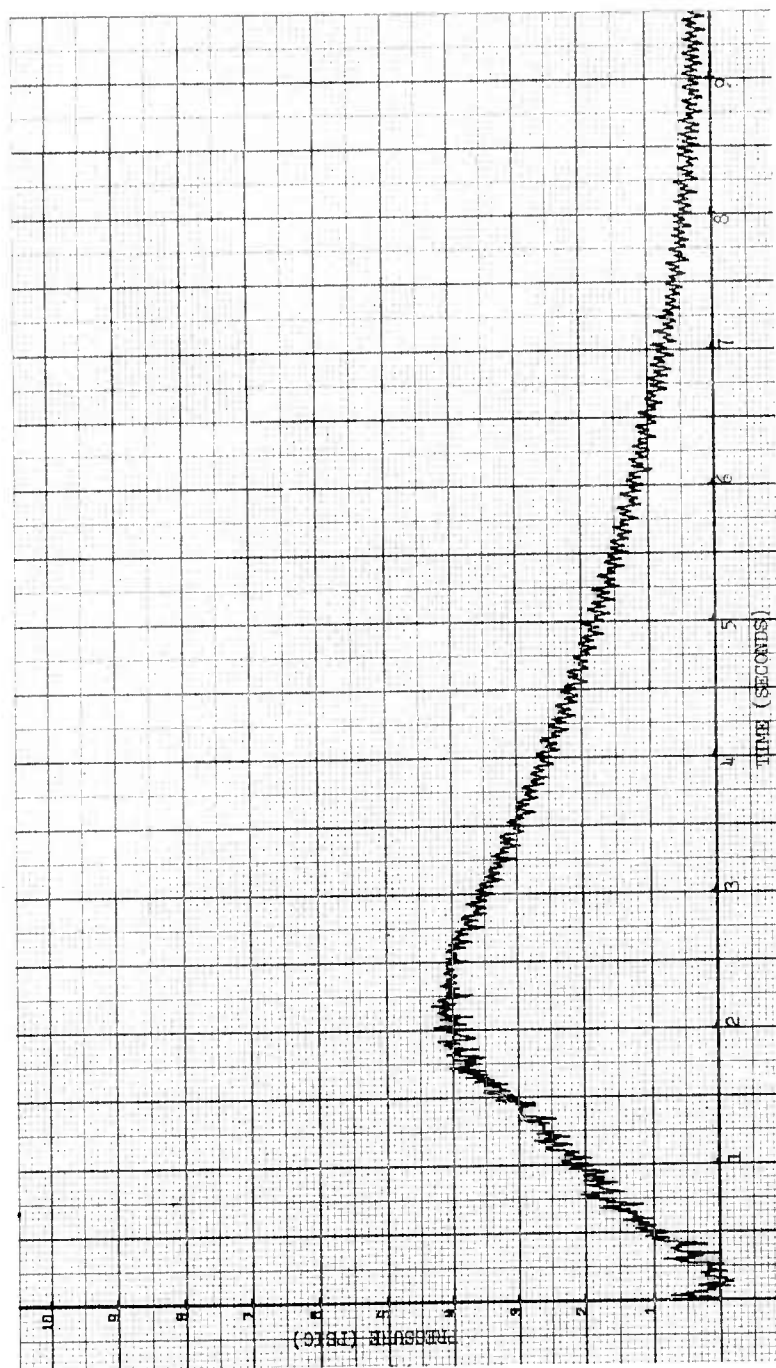


FIGURE B-5
Pressure Transducer No. 4
Test No. 1

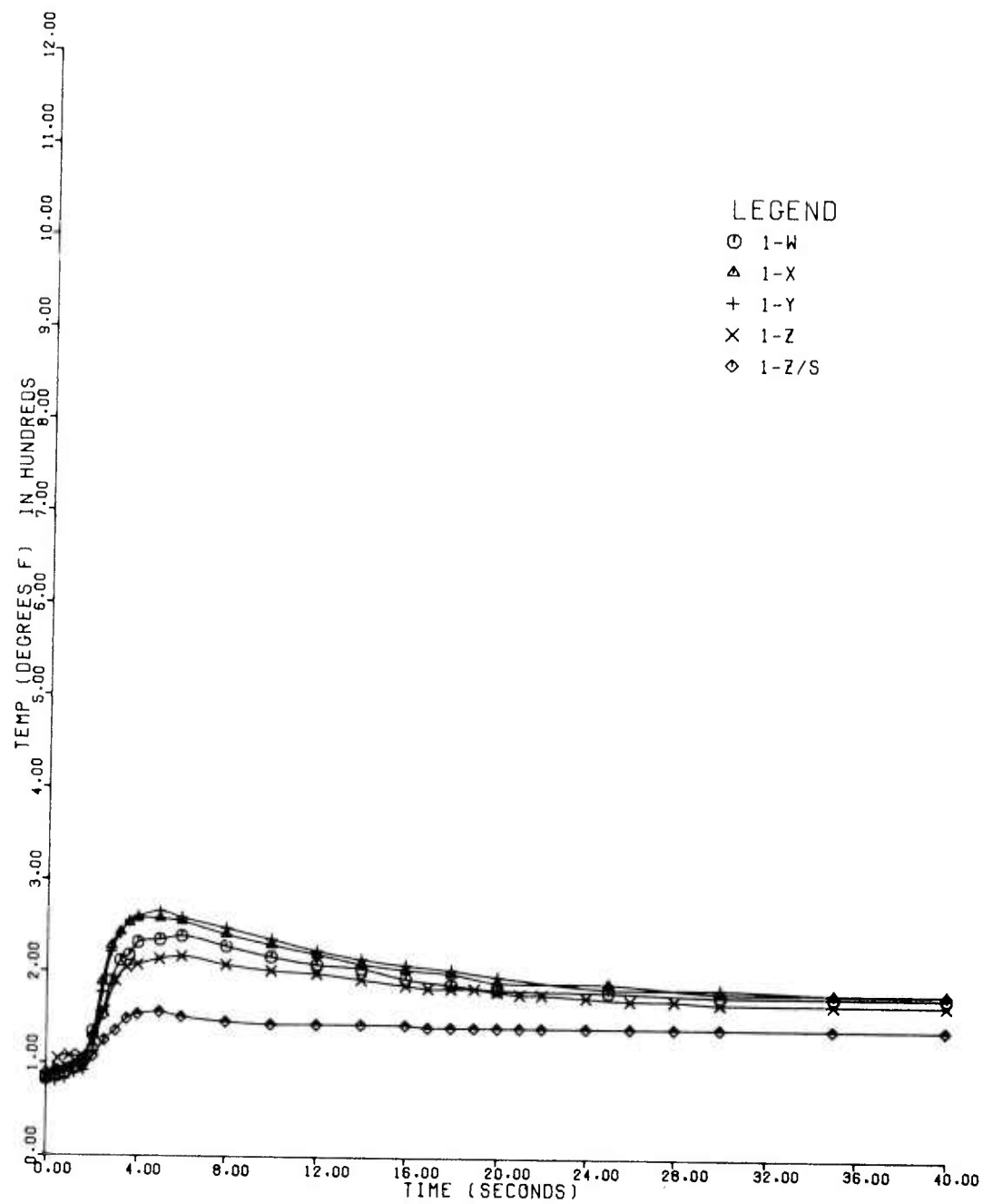


FIGURE B-6

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

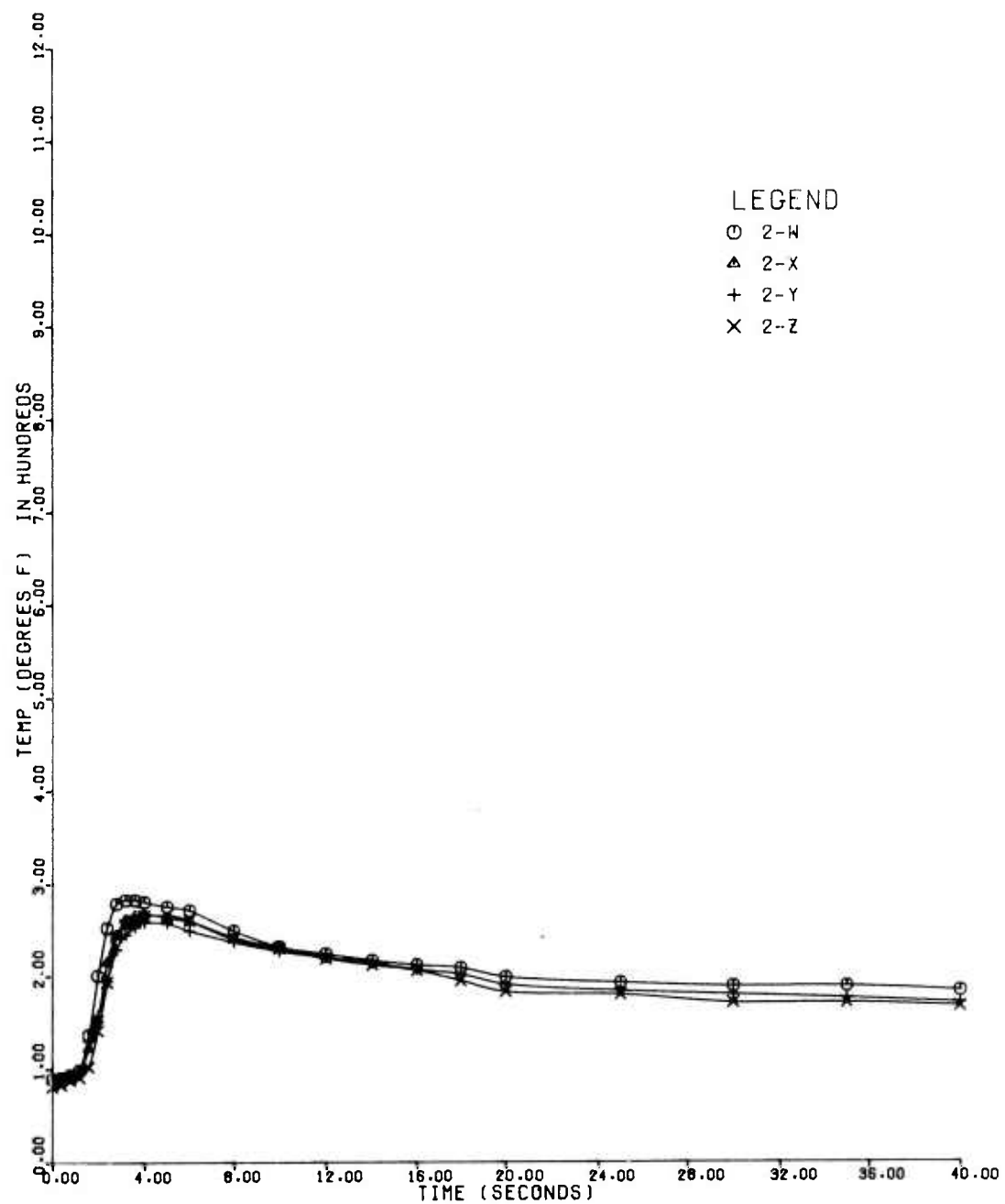


FIGURE B-7

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

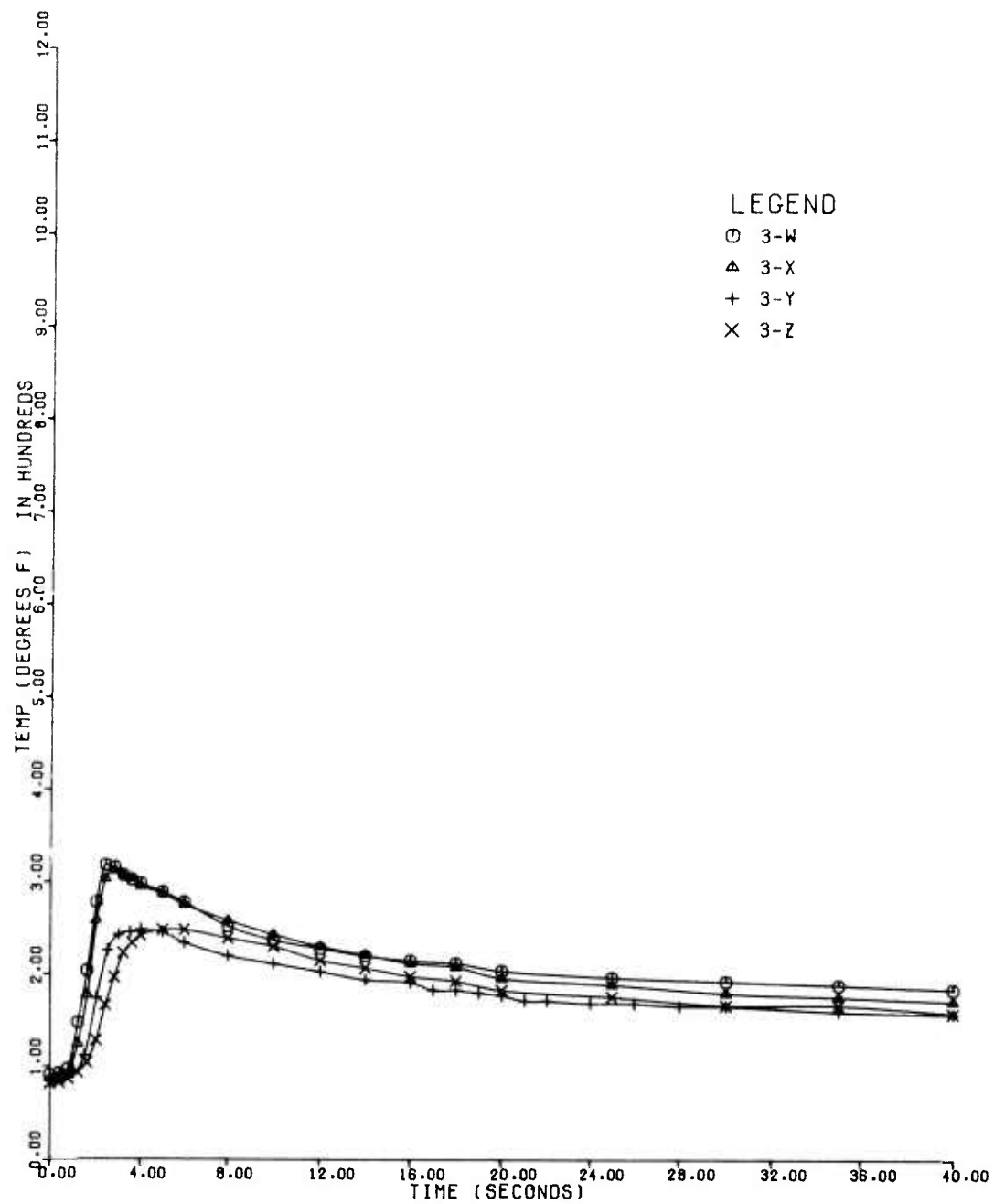


FIGURE B-8

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

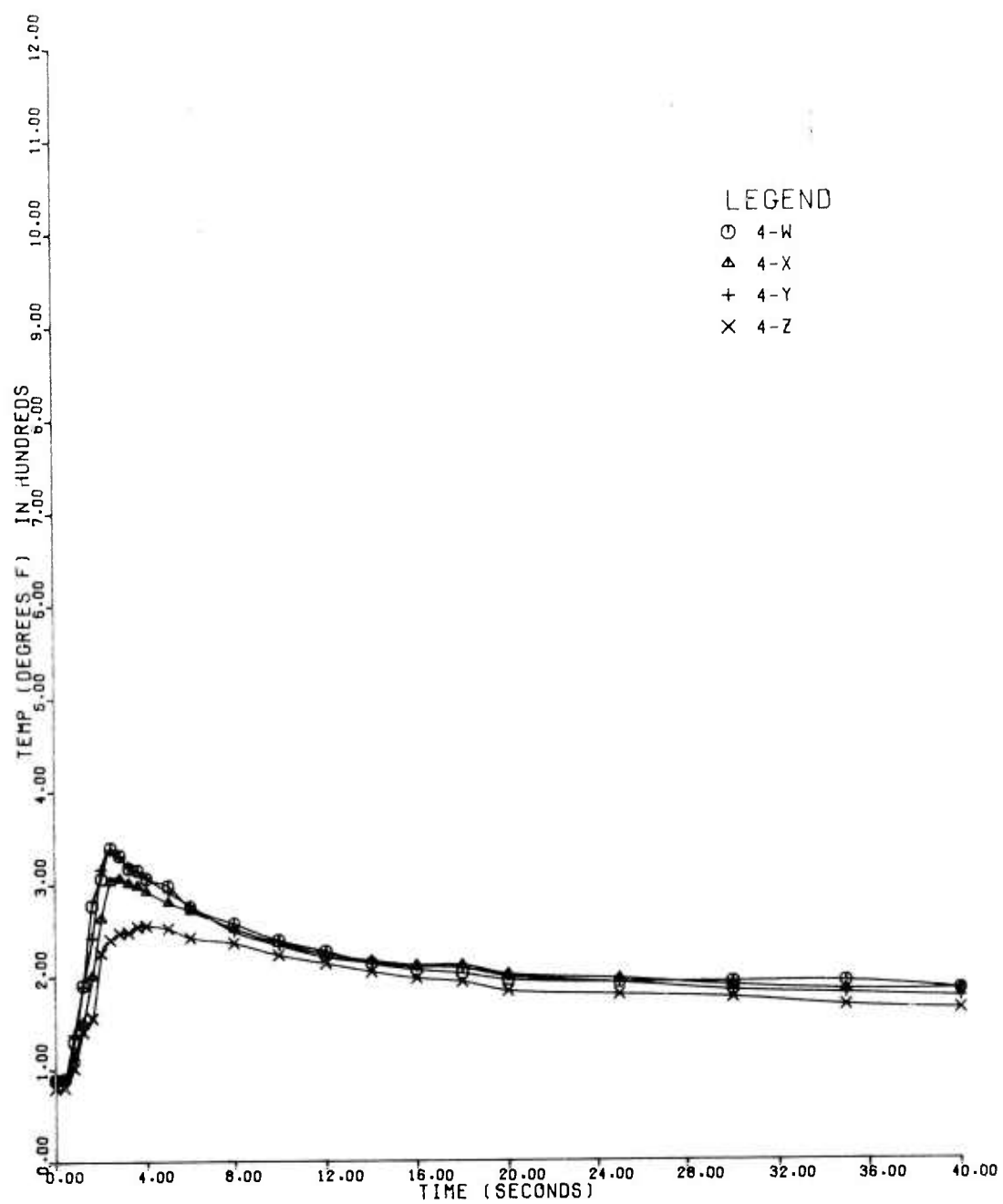


FIGURE B-9

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

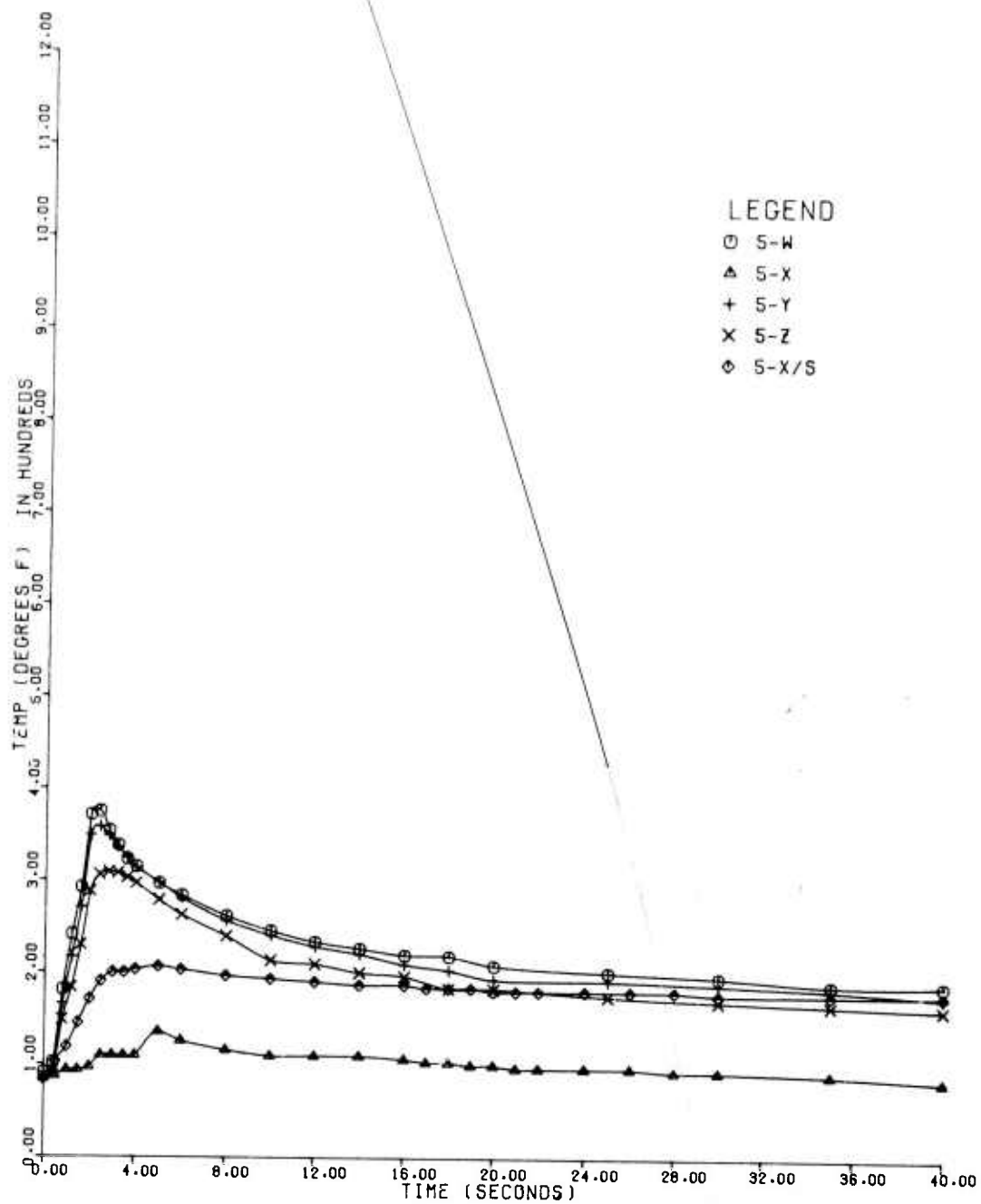


FIGURE B-10

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

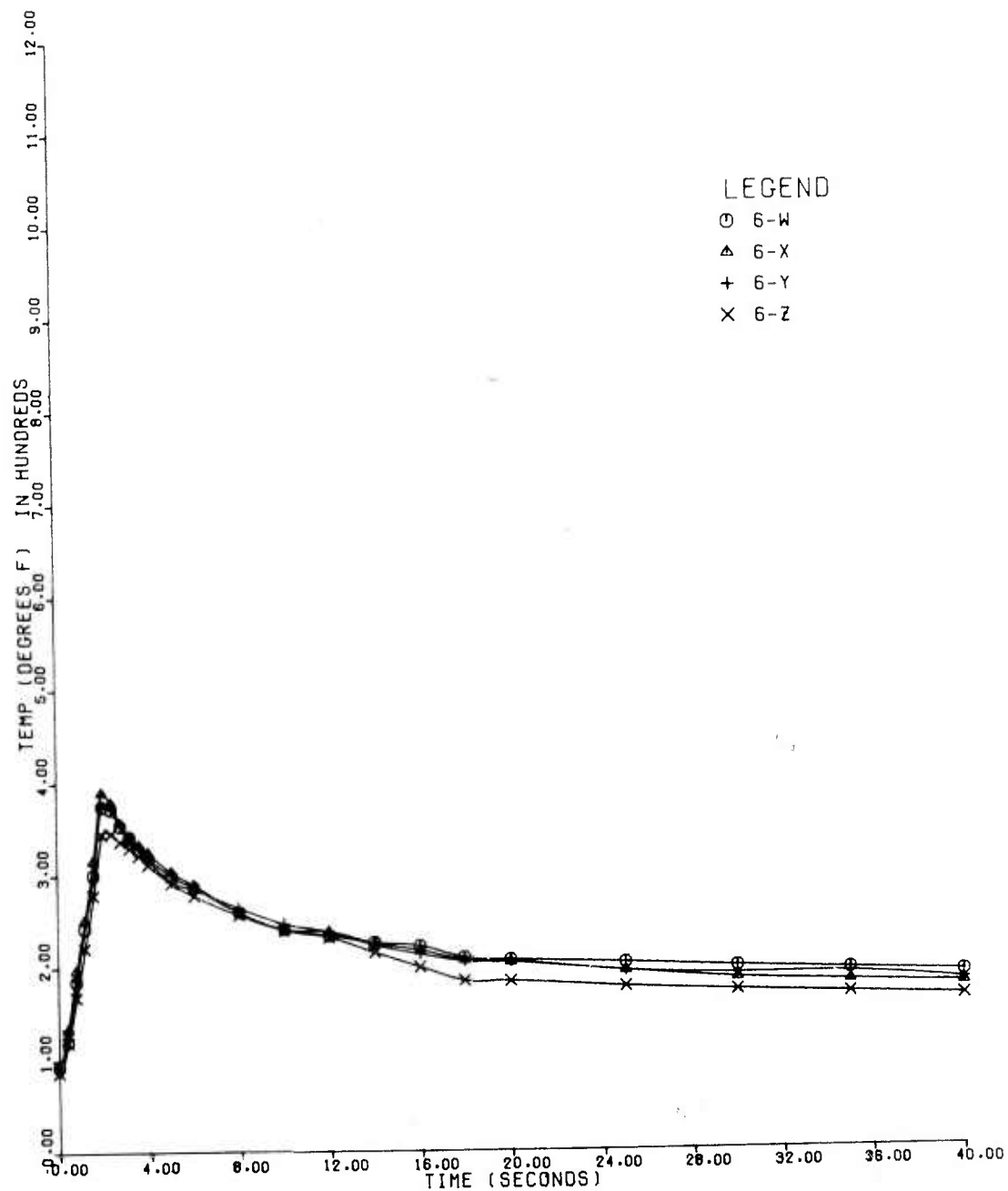


FIGURE B-11

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

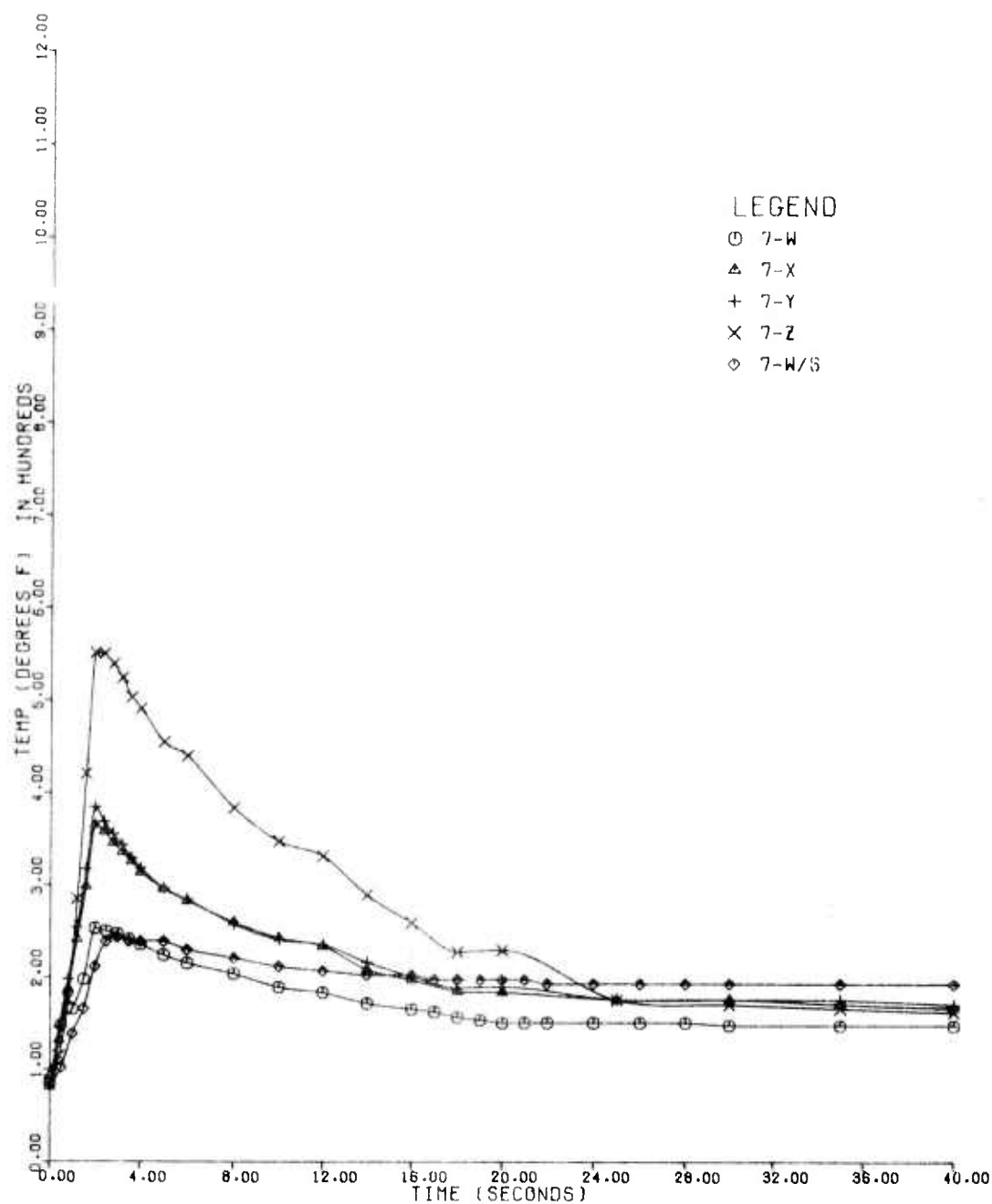


FIGURE B-12

Temperature vs-Time
CVA Magazine Test
No. 1 24 July 1973

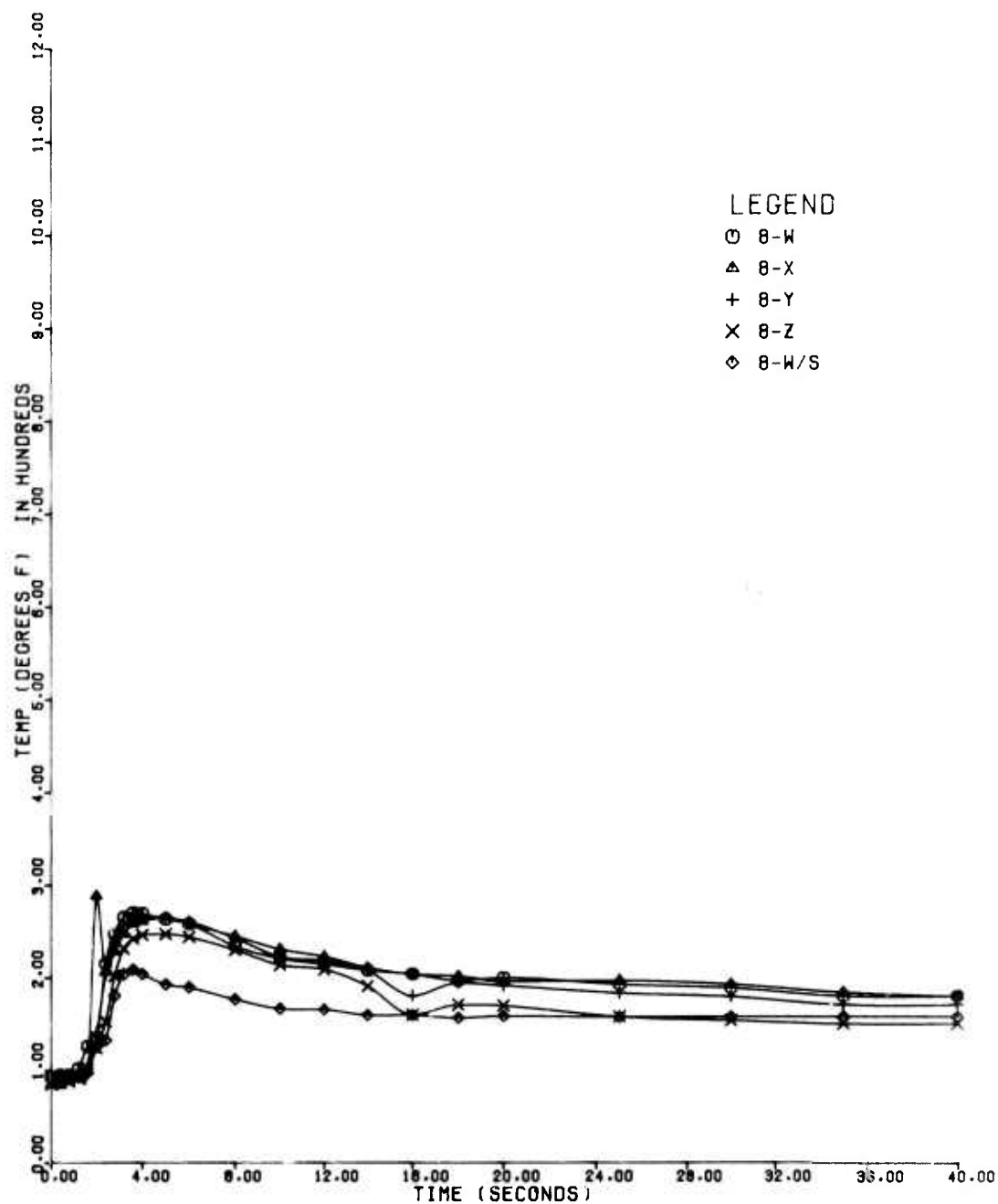


FIGURE B-13

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

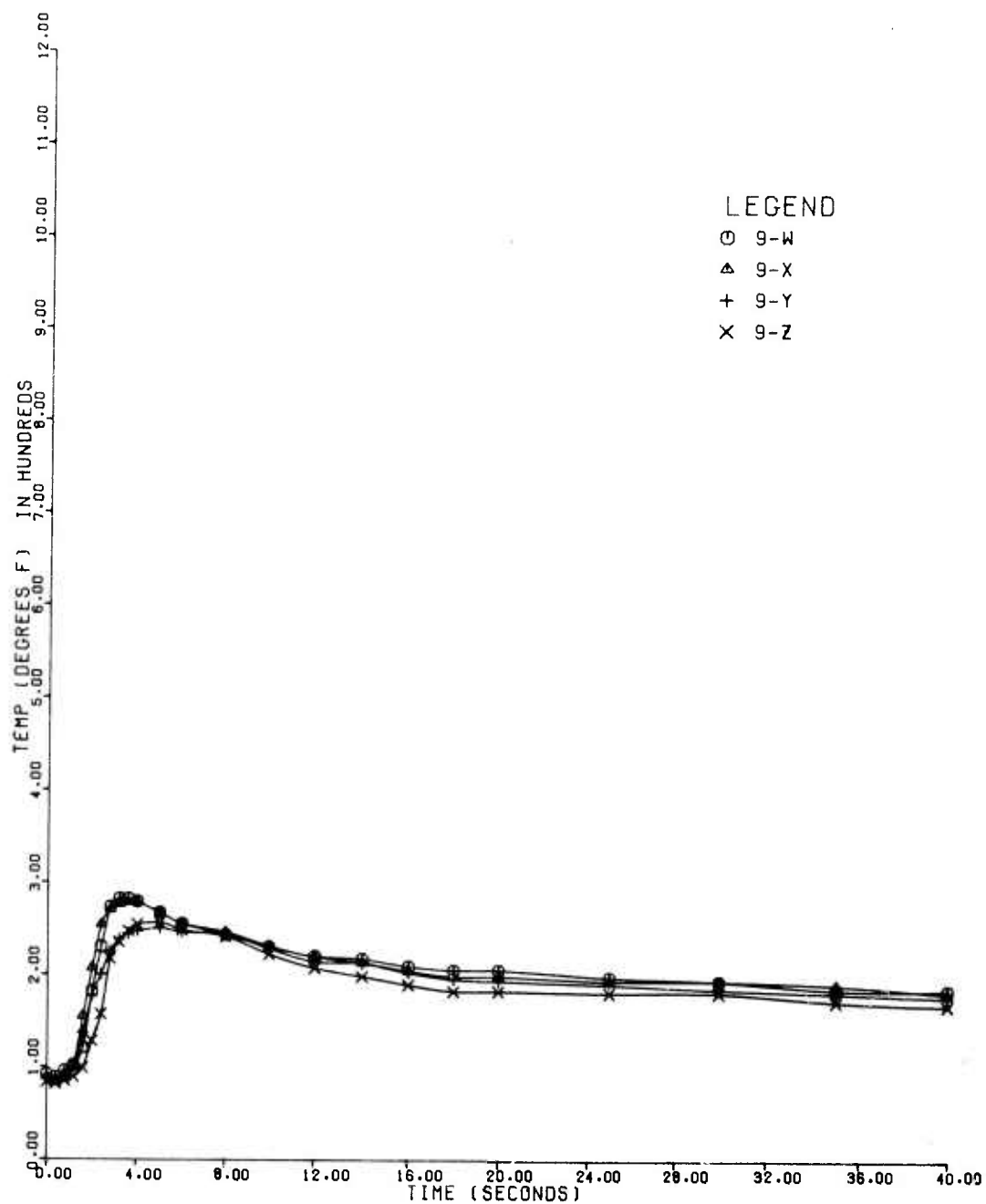


FIGURE B-14

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

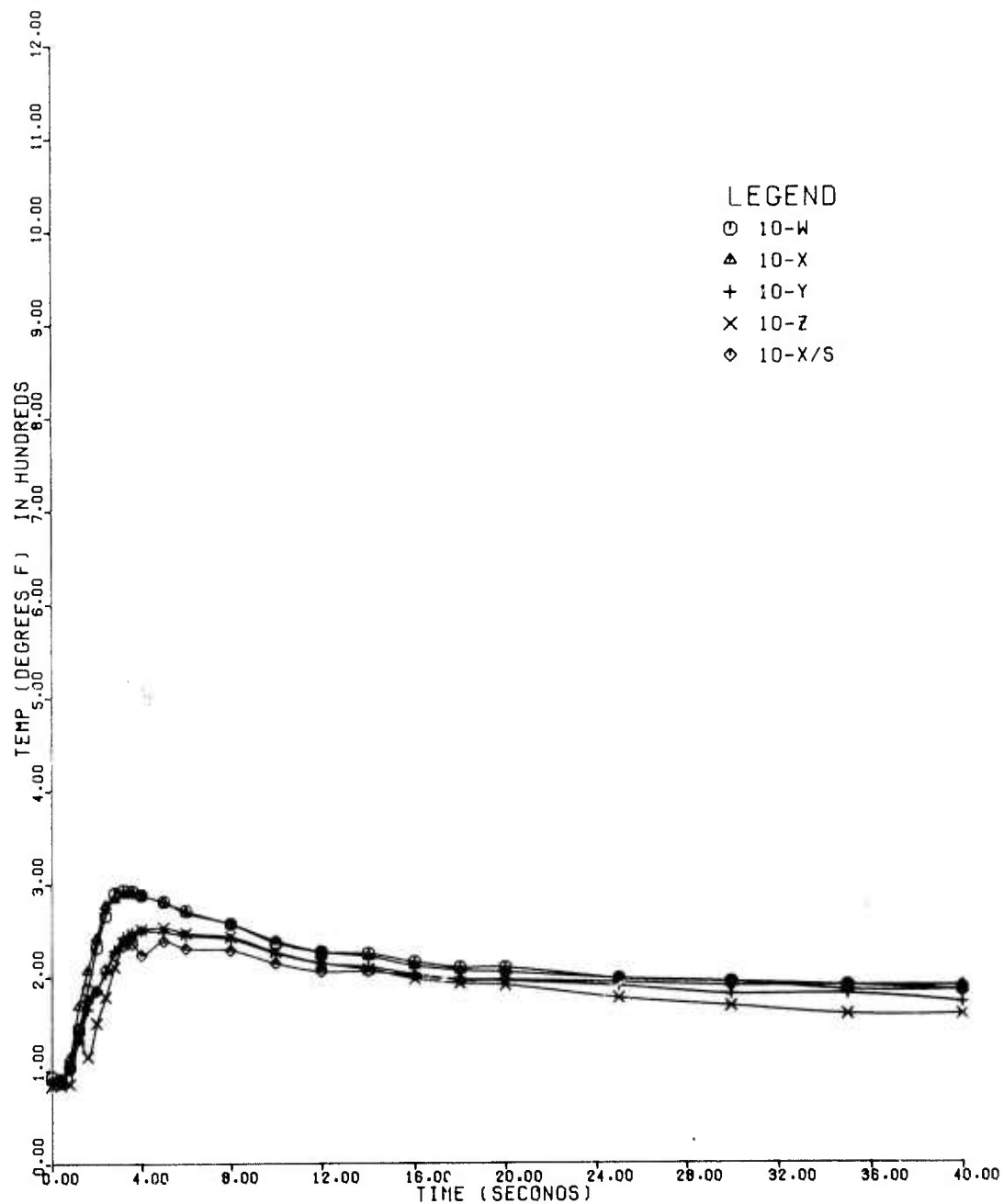


FIGURE B-15

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

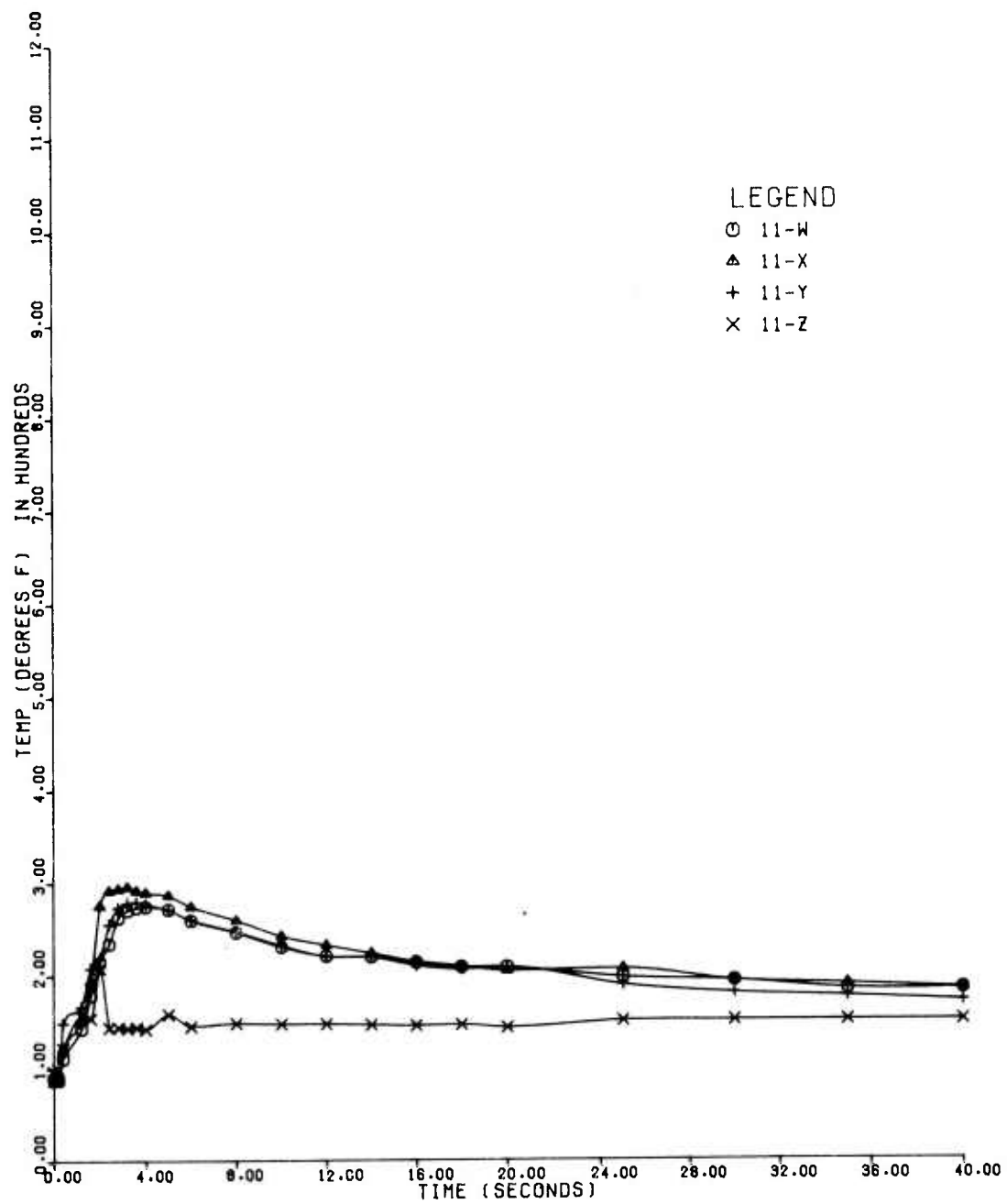


FIGURE B-16

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

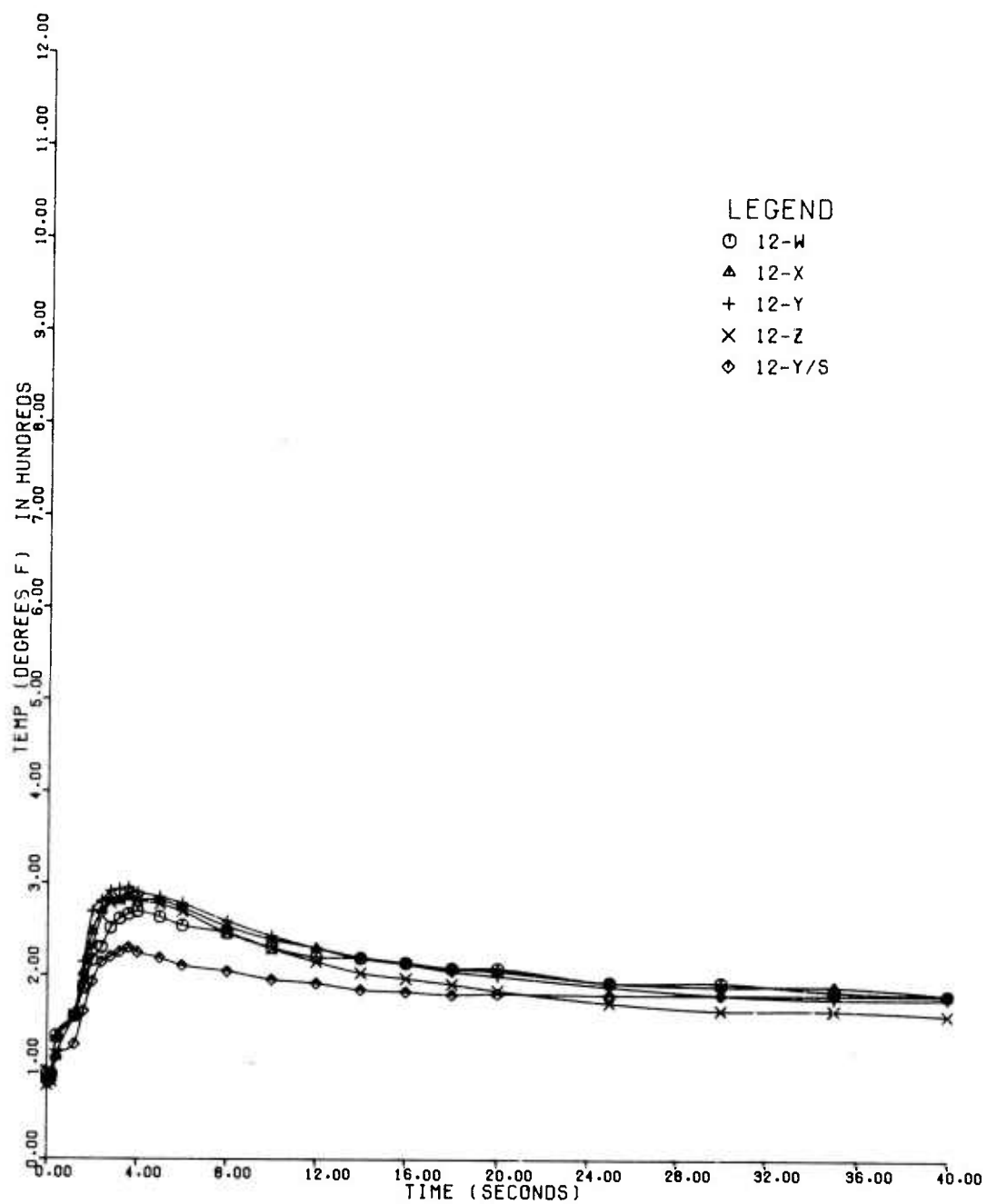


FIGURE B-17

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

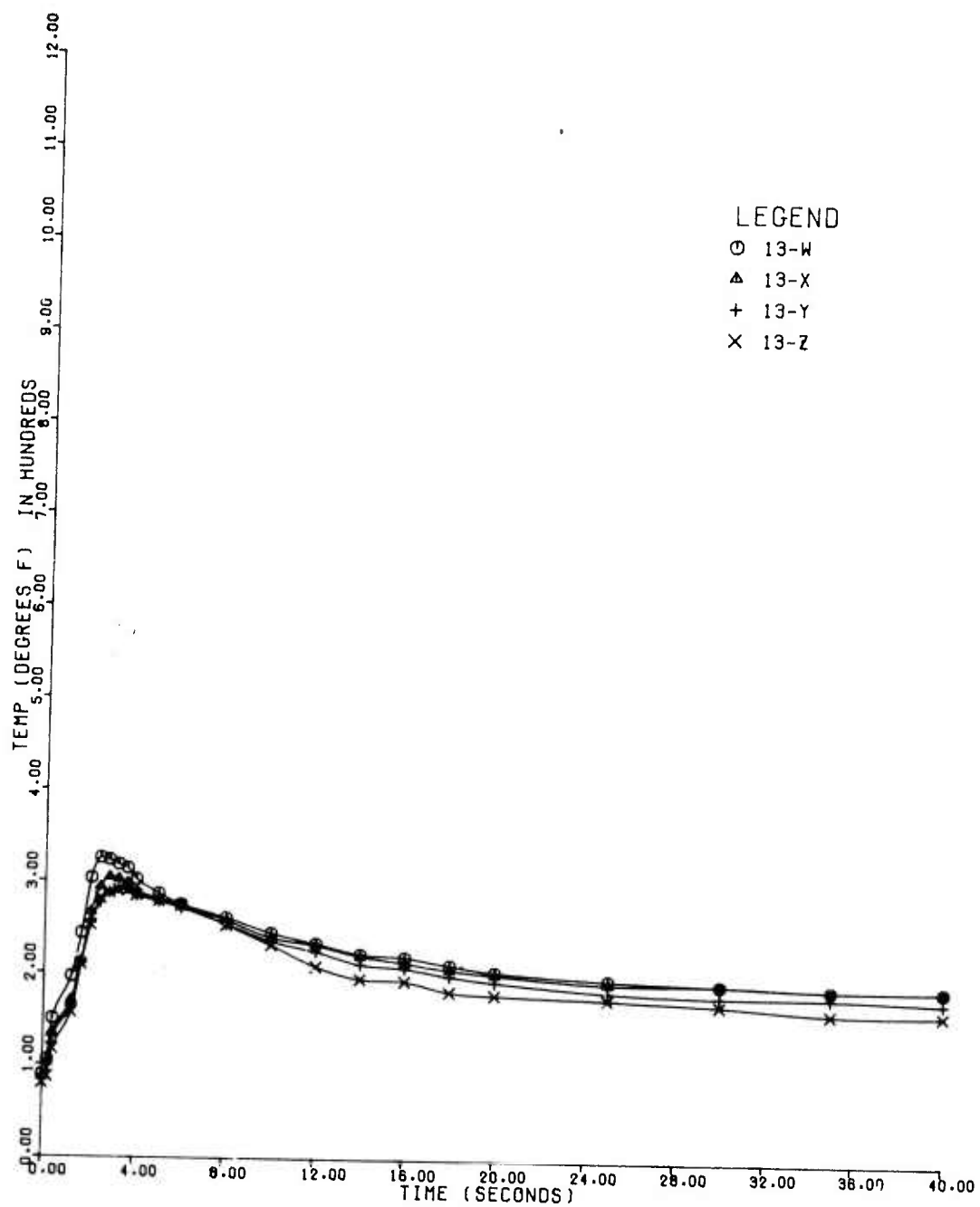


FIGURE B-18

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

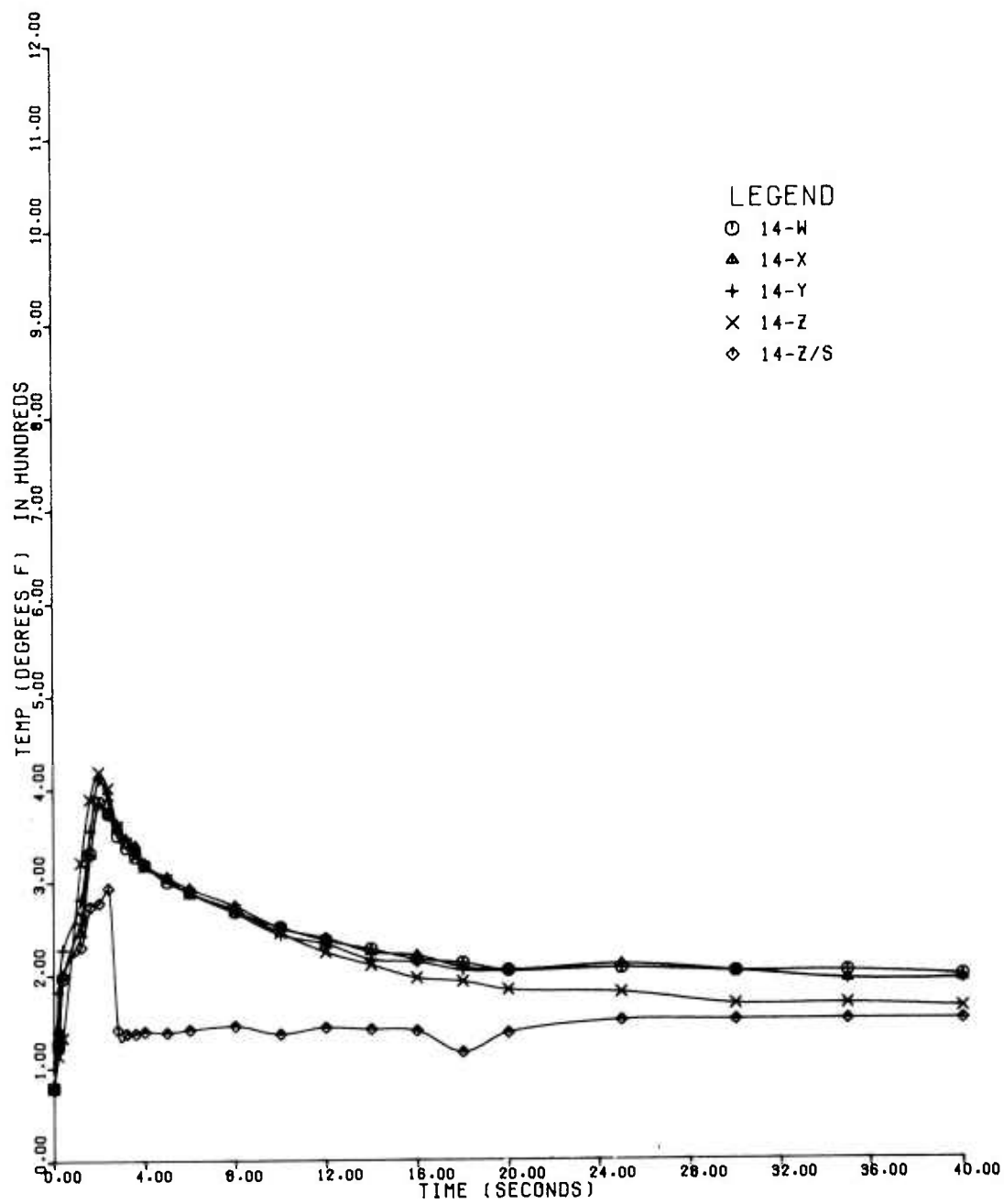


FIGURE B-19

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

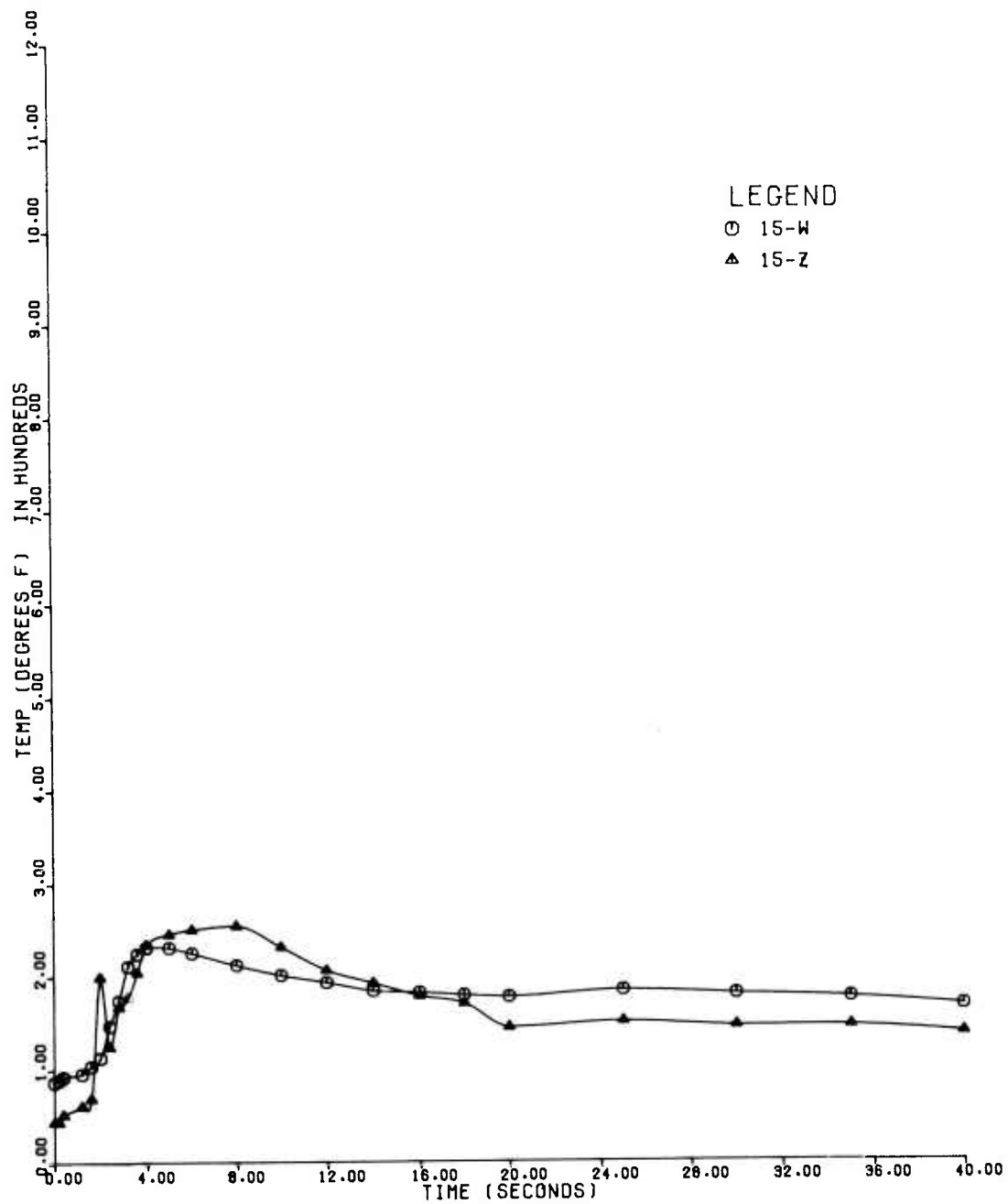


FIGURE B-20

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

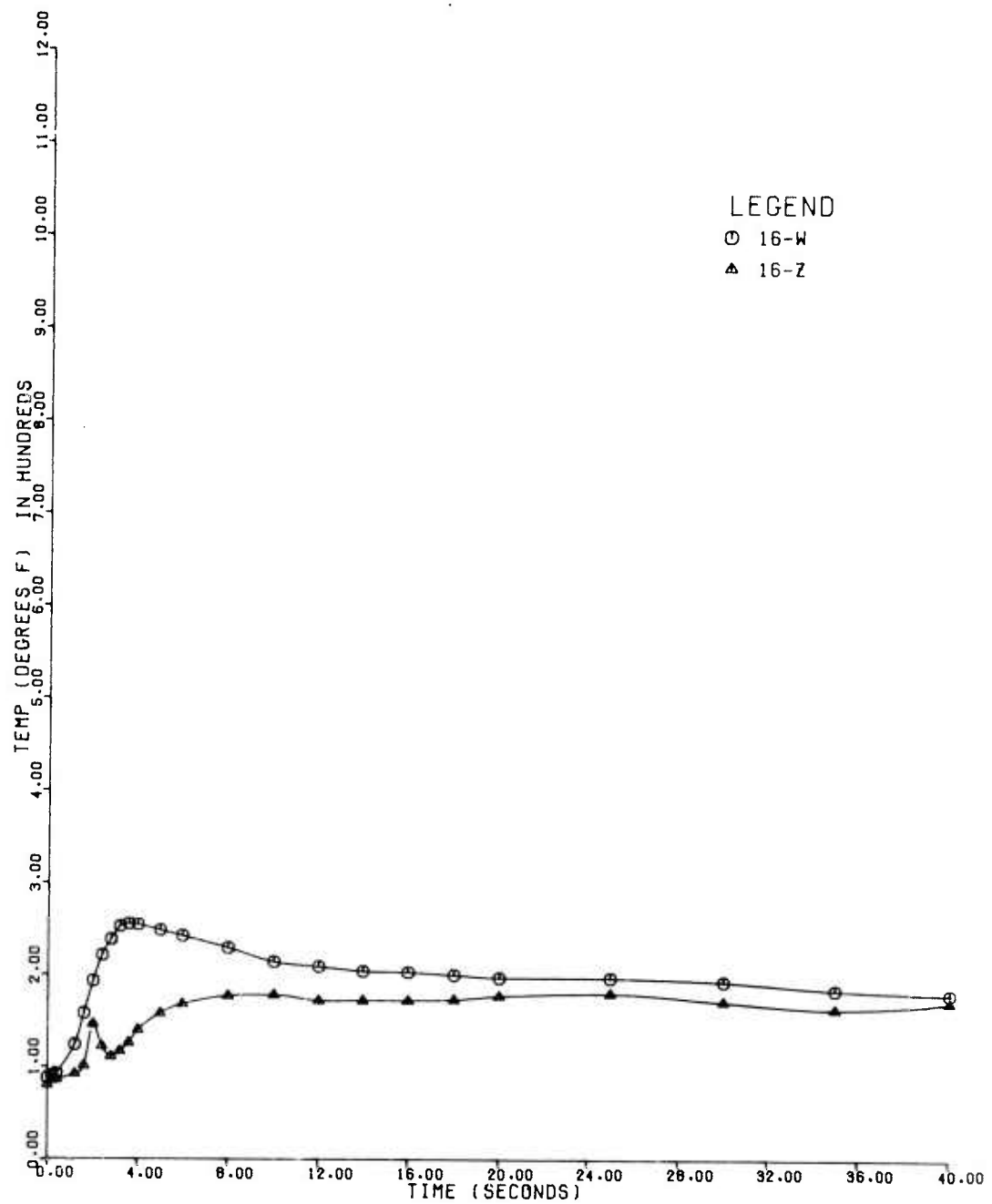


FIGURE B-21
Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

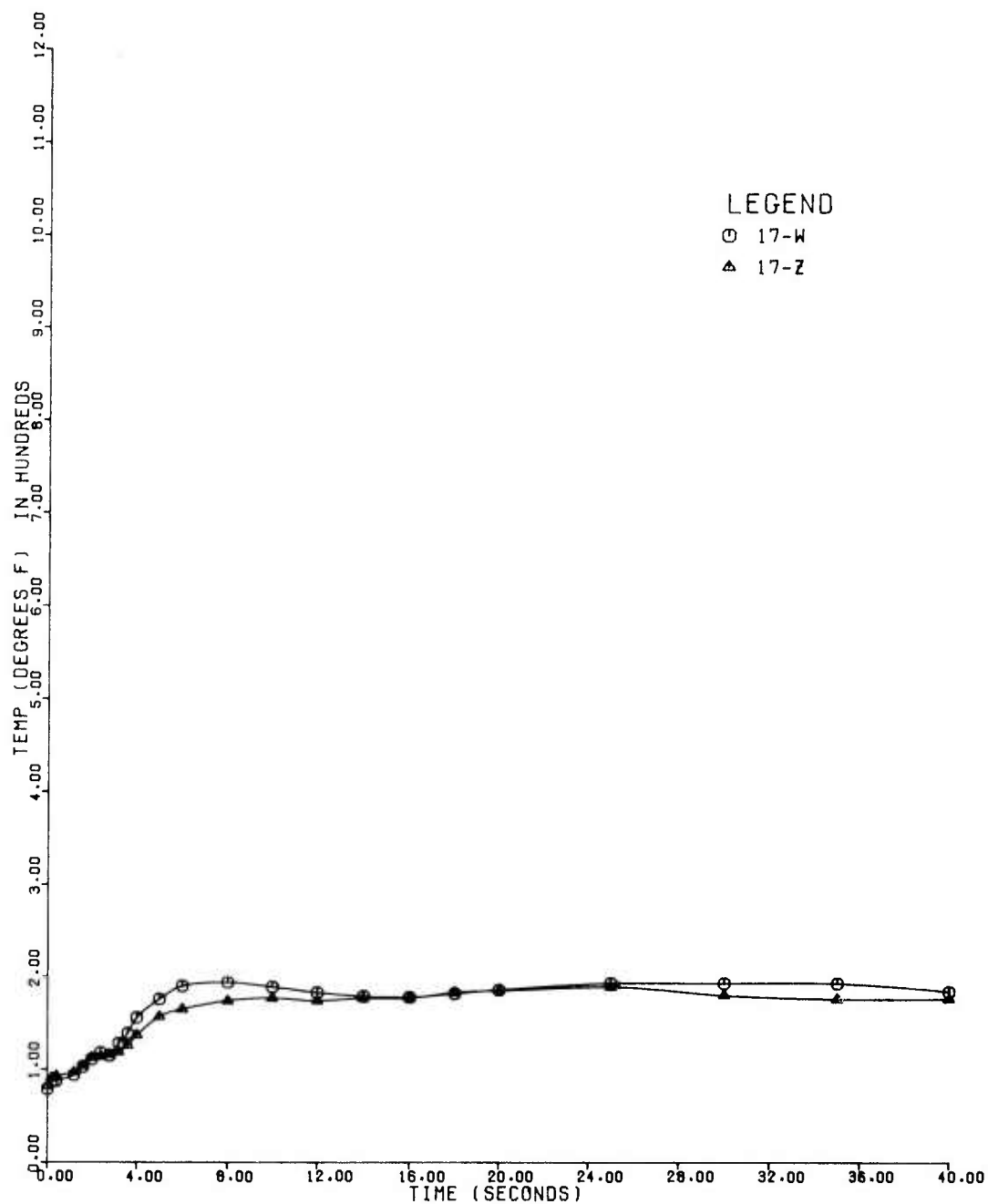


FIGURE B-22

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

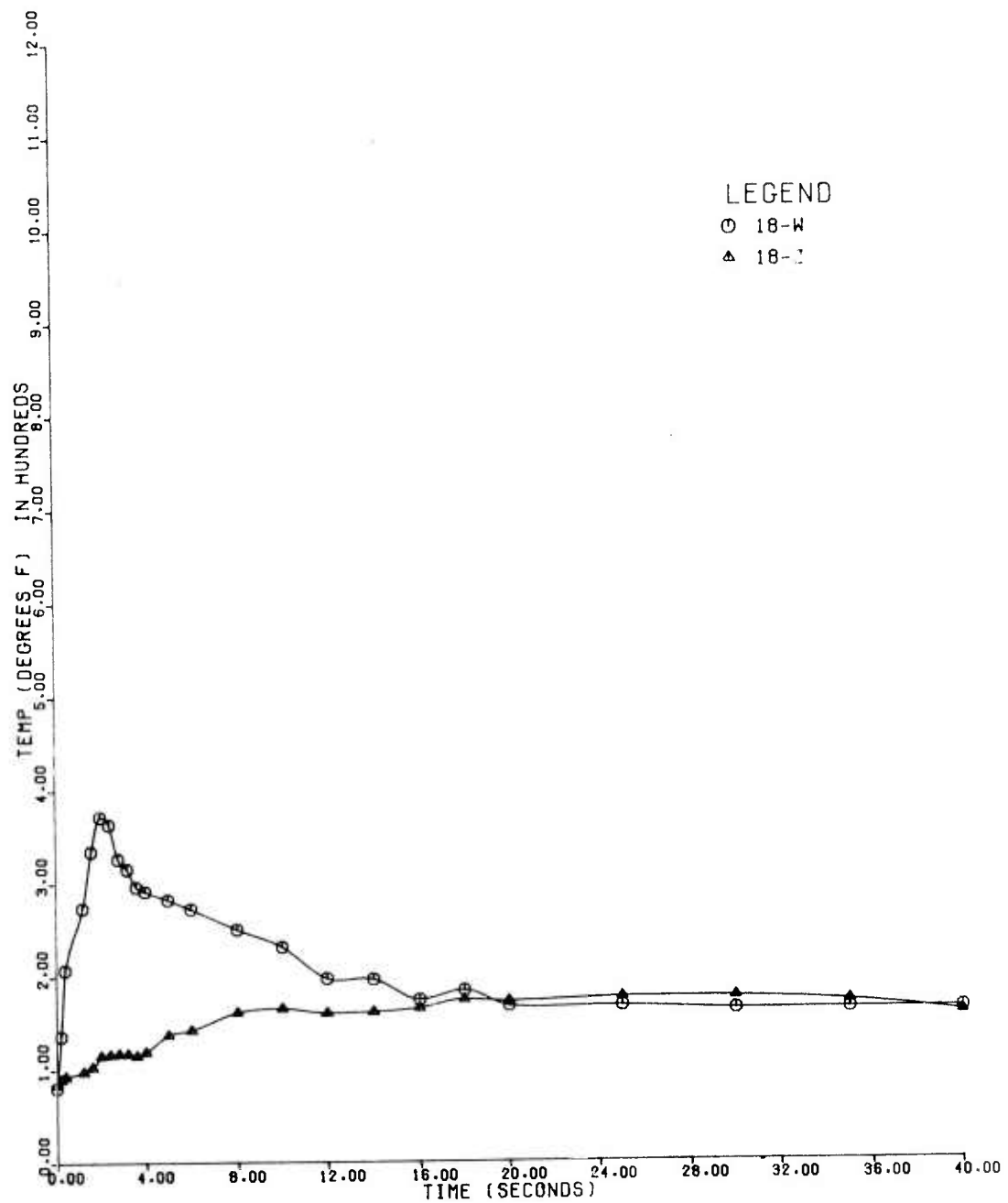


FIGURE B-23

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

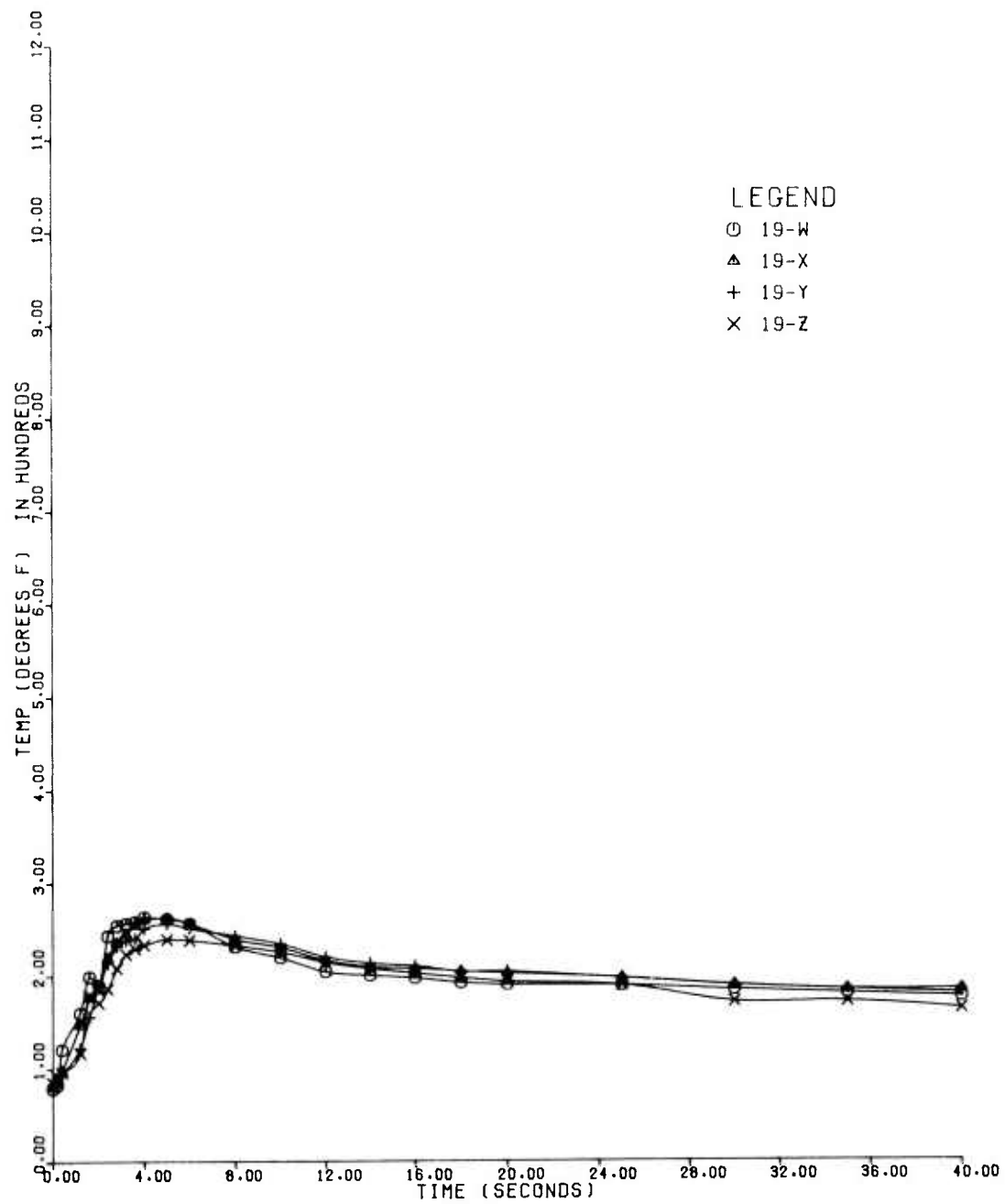


FIGURE B-24

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

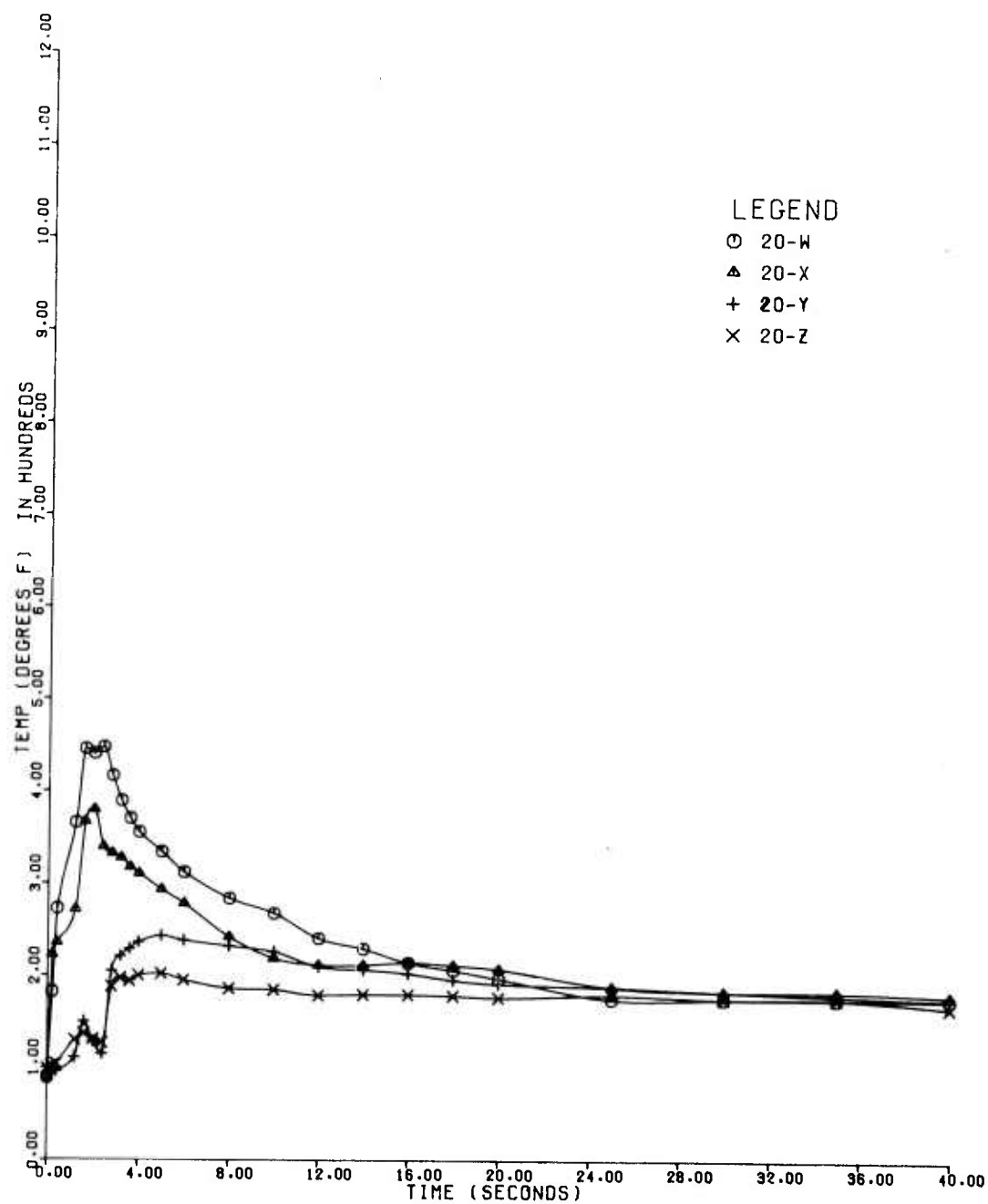


FIGURE B-25

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

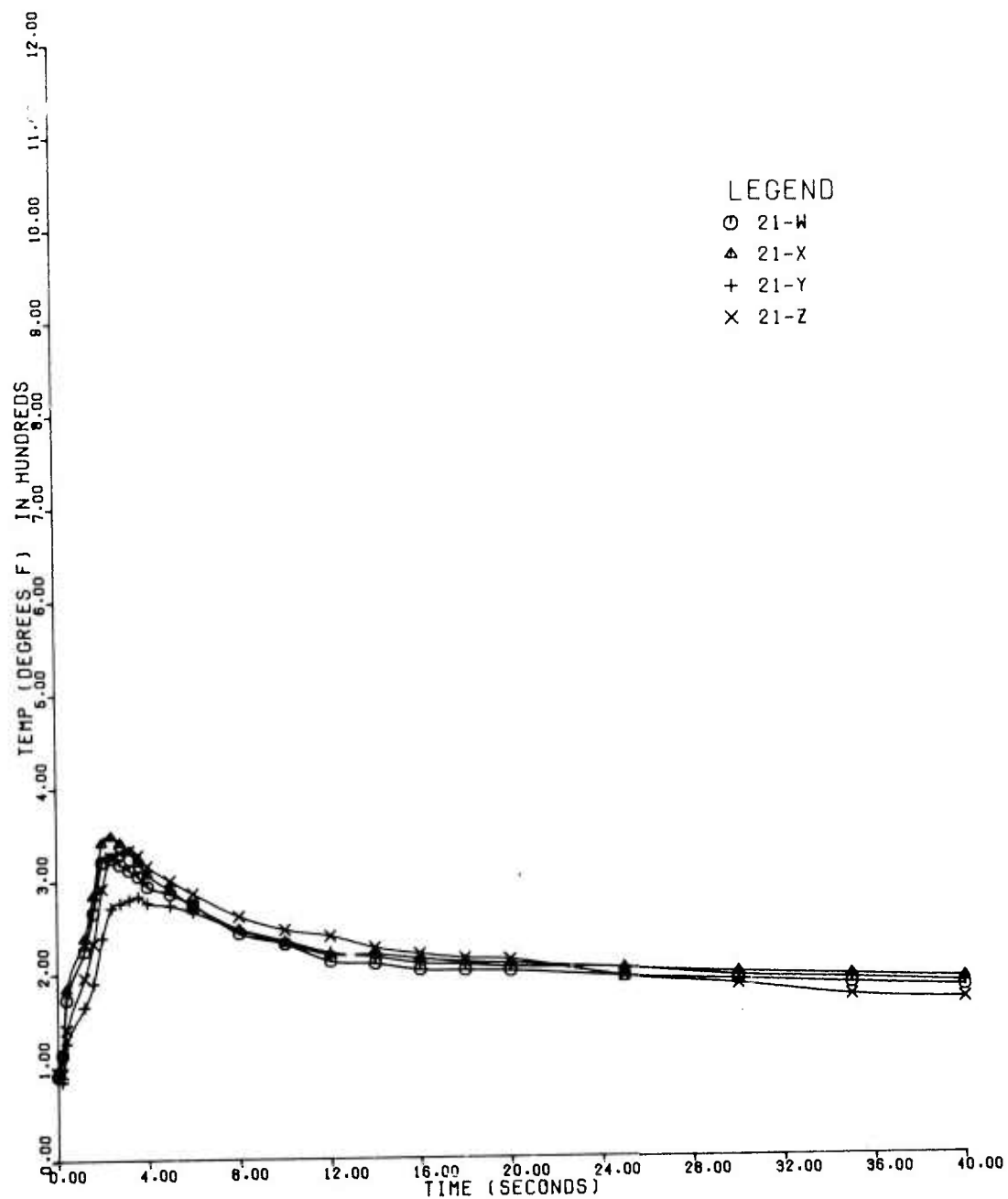


FIGURE B-26

Temperature-vs-Time
CVA Magazine Test
No. 1 24 July 1973

APPENDIX C

GAS ANALYSES OF MAGAZINE AIR SAMPLES

GAS ANALYSIS SUMMARY
Rocket/Magazine Test of 7/24/73

Outside Temperature = 87°F

Relative Humidity = 60.5%

| Location | Sample No. | Time From Ignition | H ₂ | CO ₂ | % O ₂ | N ₂ * | CO | PPM NO | NO ₂ |
|-------------|------------|--------------------|----------------|-----------------|------------------|------------------|------|--------|-----------------|
| East | 1. | 3:25 | 0.20 | 0.09 | 19.5 | Balance | 0.17 | — | — |
| Bottom | 5. | 14:30 | 0.29 | 0.12 | 21.3 | Balance | 0.21 | — | — |
| | Bubbler | — | — | — | — | — | — | 1.3 | 1.1 |
| East | 2. | 4:08 | 0.28 | 0.14 | 17.5 | Balance | 0.3 | — | — |
| Top | 6. | 15:15 | 0.30 | 0.15 | 18.0 | Balance | 0.36 | — | — |
| | Bubbler | — | — | — | — | — | — | 2.3 | 2.1 |
| West | 4. | 7:05 | 0.29 | 0.13 | 17.8 | Balance | 0.29 | — | — |
| Bottom | 7. | 18:30 | 0.13 | 0.05 | 9.9 | Balance | 0.16 | — | — |
| | Bubbler | — | — | — | — | — | — | 4.0 | 3.2 |
| West | 3. | 6:00 | 0.25 | 0.13 | 19.6 | Balance | 0.26 | — | — |
| Top | 8. | 19:15 | 0.06 | 0.08 | 17.8 | Balance | 0.09 | — | — |
| | Bubbler | — | — | — | — | — | — | 5.1 | 6.1 |
| Outside Air | 9. | 8:00 | Nil | 0.03 | 20.9 | Balance | Nil | — | — |

*Also includes unanalyzed gases like Argon (nat. abund. = 0.94%) and HCL

GAS ANALYSIS SUMMARY
Rocket/Magazine Test of 8/7/73

Outside Temperature = 90°F

Relative Humidity (Outside) = 58%

| Location | Sample No. | Time From Ignition | % by Vol. | | | | CO | PPM | |
|-------------|------------|-----------------------|----------------|-----------------|----------------|------------------|------|-----|-----------------|
| | | | H ₂ | CO ₂ | O ₂ | N ₂ * | | NO | NO ₂ |
| West Top | 3. | 4:10 | 0.40 | 0.52 | 19.2 | 78.4 | 1.52 | — | — |
| West Top | 7. | 12:30 | 0.37 | 0.47 | 19.3 | 78.5 | 1.37 | — | — |
| West Top | Bubbler | — | — | — | — | — | — | 3.7 | 6.3 |
| West Bottom | 4. | 5:40 | 0.38 | 0.52 | 19.0 | 78.6 | 1.47 | — | — |
| West Bottom | 8. | 11:35 | 0.33 | 0.40 | 18.8 | 79.4 | 1.03 | — | — |
| West Bottom | Bubbler | — | — | — | — | — | — | 7.4 | 7.3 |
| East Top | 1. | 7:25 | 0.37 | 0.62 | 19.2 | 78.5 | 1.35 | — | — |
| East Top | 5. | 13:50 | 0.35 | 0.46 | 20.1 | 77.8 | 1.32 | — | — |
| East Top | Bubbler | — | — | — | — | — | — | 3.6 | 1.3 |
| East Bottom | 2. | 9:00 | 0.29 | 0.38 | 19.7 | 78.6 | 1.04 | — | — |
| East Bottom | 6. | 14:55 | 0.23 | 0.32 | 20.4 | 78.2 | 0.84 | — | — |
| East Bottom | Bubbler | — | — | — | — | — | — | 4.4 | 1.0 |

*Balance nitrogen includes unanalyzed gases. The natural abundance of gases in the atmosphere by volume are: N₂ 78.1%, O₂ 20.95%, CO₂ 0.033%, A 0.93%, H₂ 0.5 ppm, CH₄ 2 ppm, and N₂ O 0.5 ppm (Reference: F. C. Weast, editor, *Handbook of Chemistry and Physics*, 49th Edition, The Chemical Rubber Company, 1968, p. F151).

APPENDIX D

**PHOTOGRAPHS OF
MAGAZINE INSTRUMENTATION AND
ORDNANCE CONFIGURATION**



FIGURE D-1
Magazine Instrumentation Array and Ordnance Configuration
Test No. 1 24 July 1973

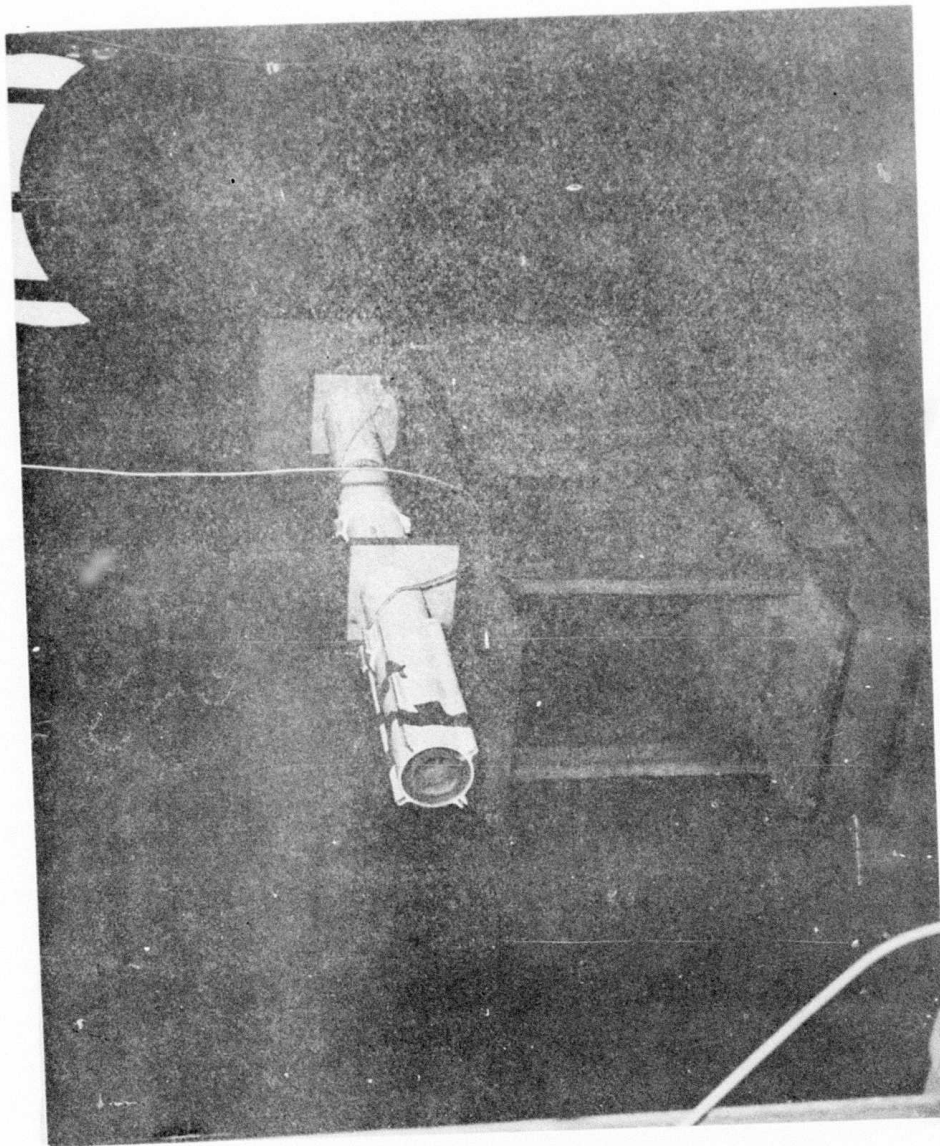


FIGURE D-2

Active SIDEWINDER MK 17 MOD 5 Motor Mounted on the Static Thrust Stand
Tests No. 1 and No. 2

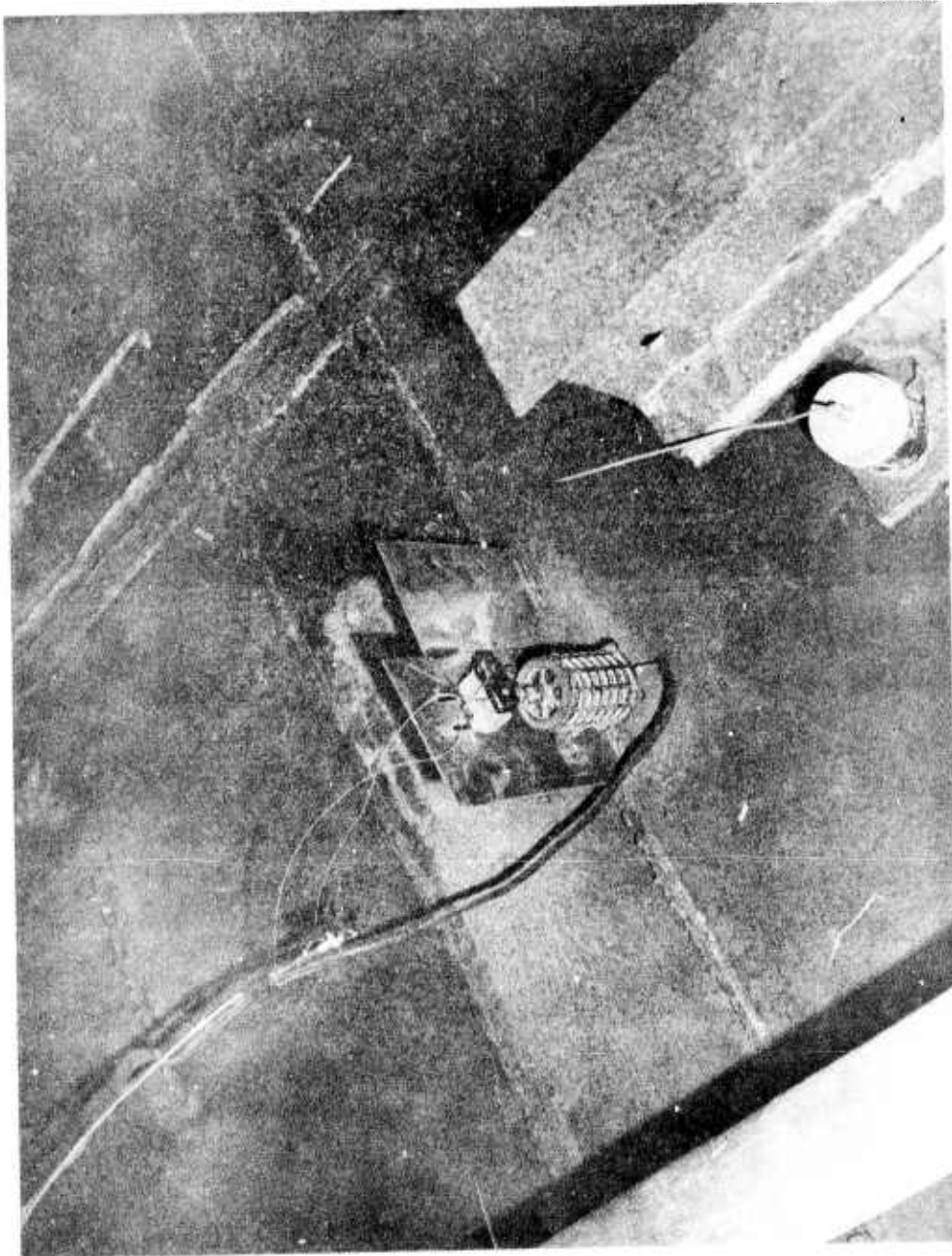


FIGURE D-3
Sylphon Detector and Microswitch Installation



FIGURE D-4

Electron Microscope Photograph of Ruptured Vent Shear-Bolt
Test No. 2 7 August 1973

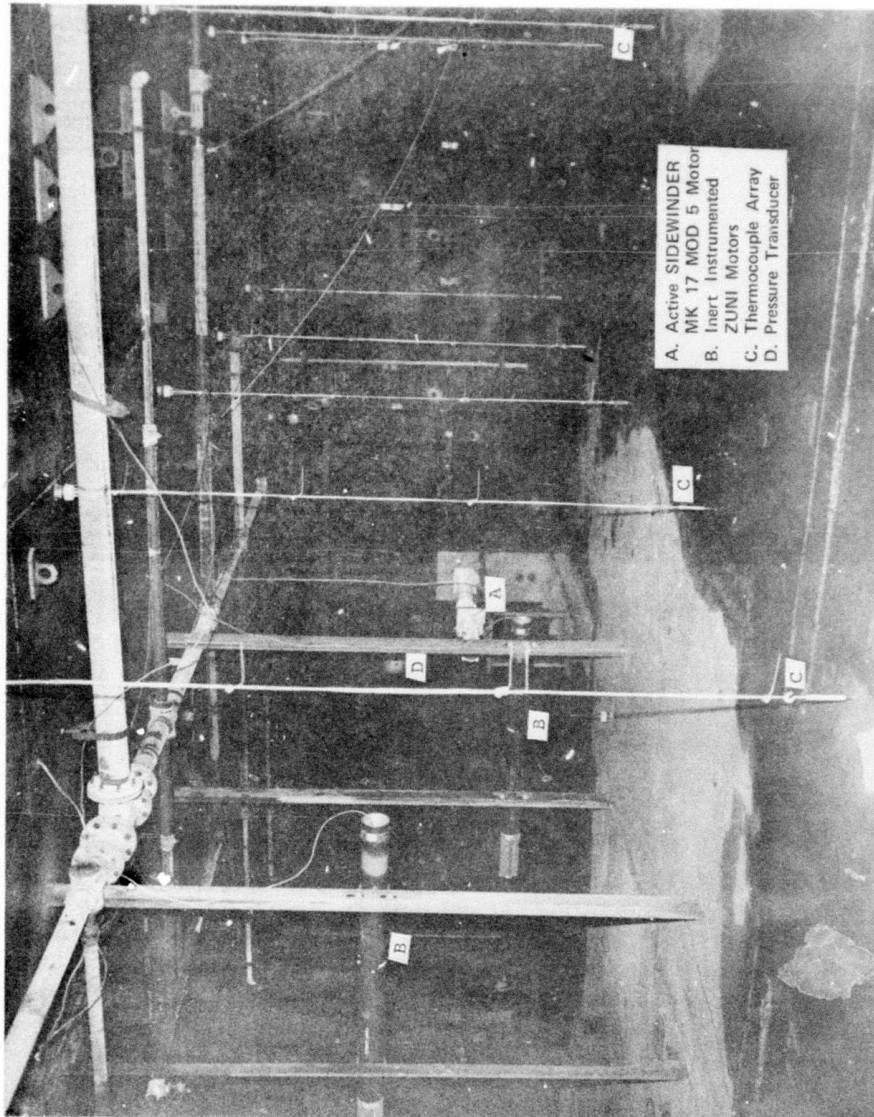


FIGURE D-5
Magazine Instrumentation Array and Ordnance Configuration
Test No. 2

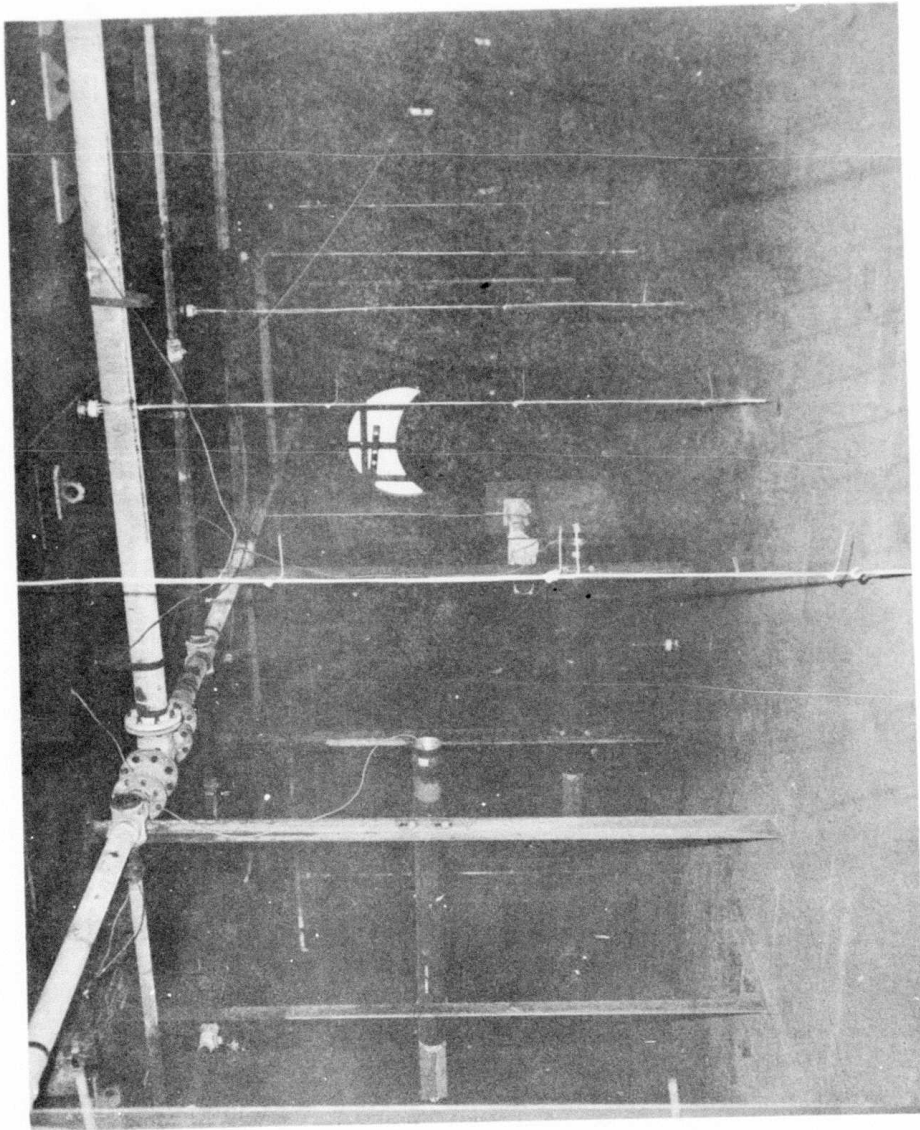


FIGURE D-6
Magazine Instrumentation and Ordnance Configuration
Test No. 2

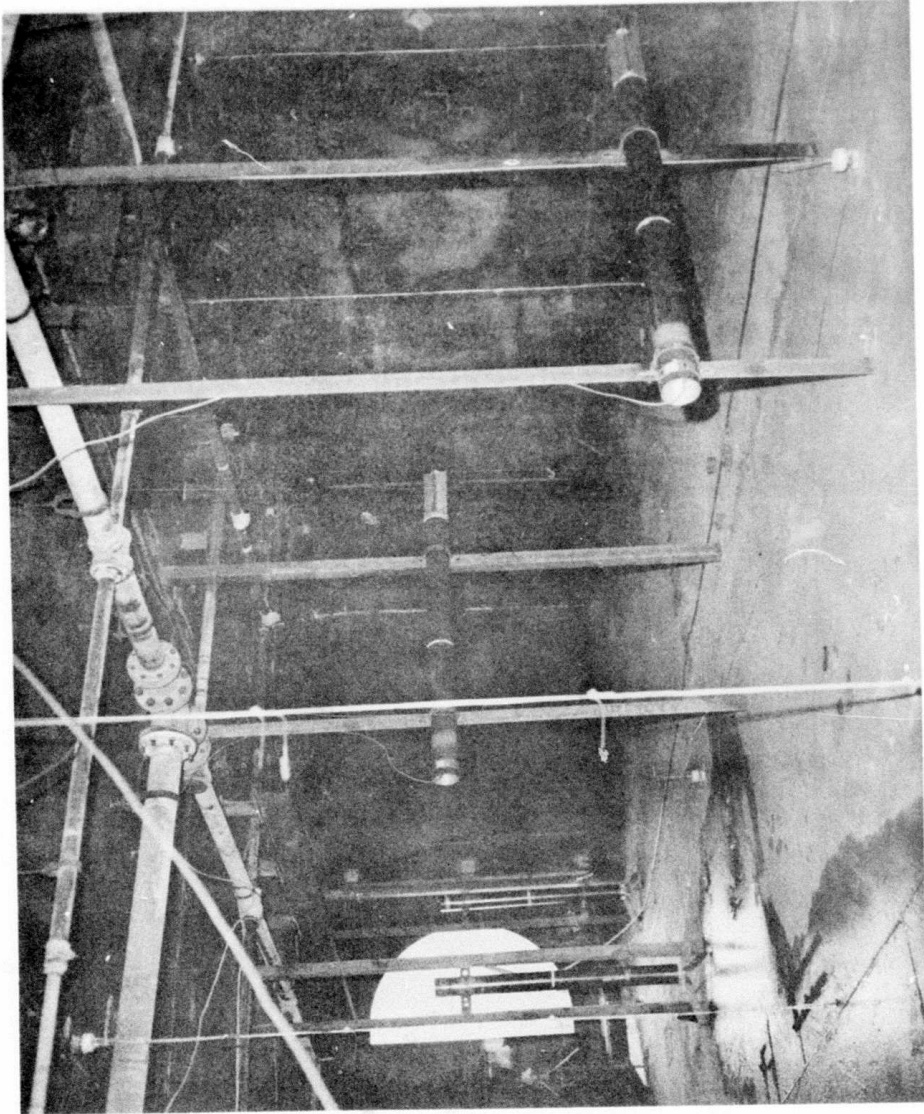


FIGURE D-7
Magazine Instrumentation Array and Ordnance Configuration
Test No. 2

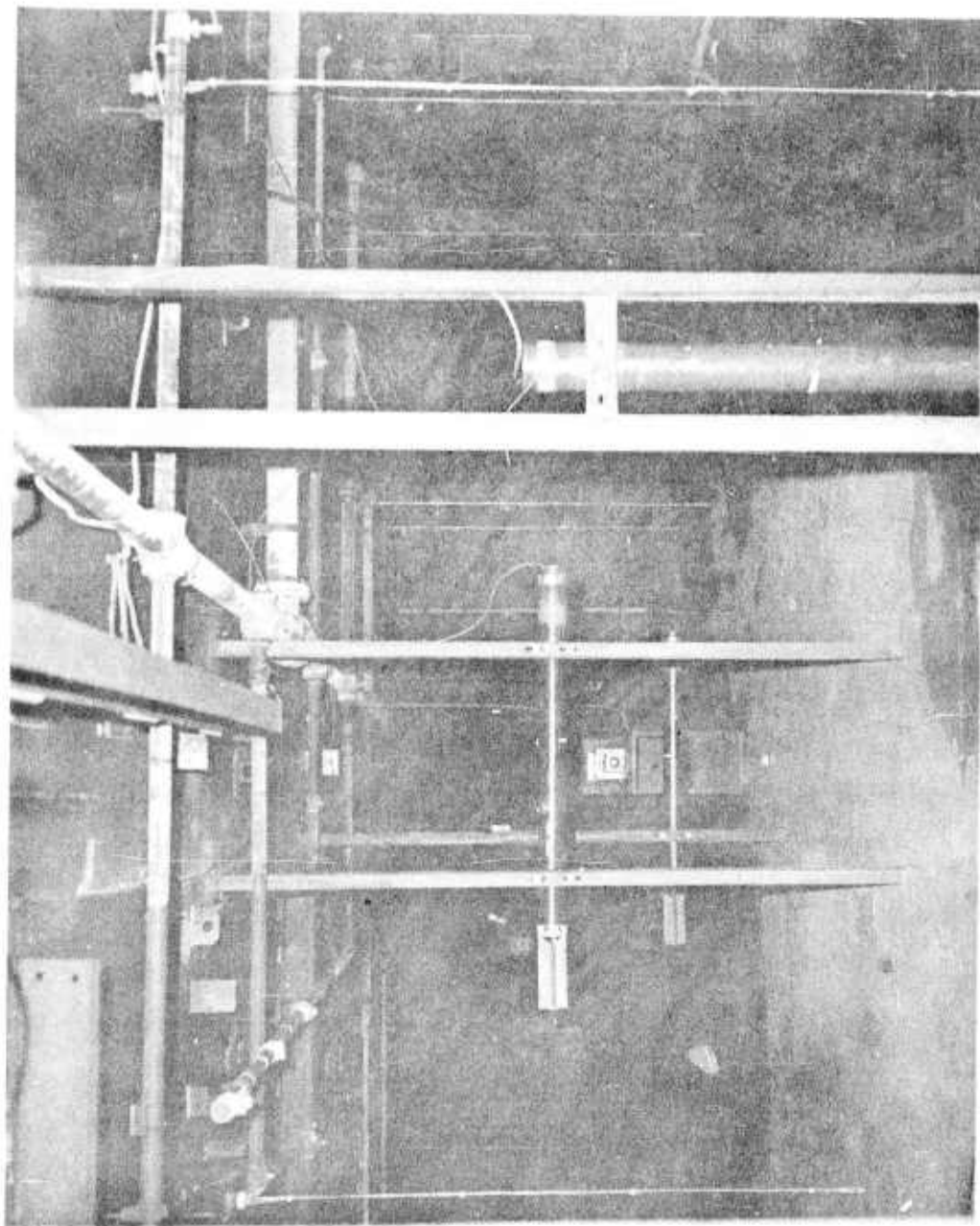


FIGURE D-8
Magazine Instrumentation Array and Ordnance Configuration
Test No. 2

APPENDIX E
TEST DATA OBTAINED DURING TEST NO. 2

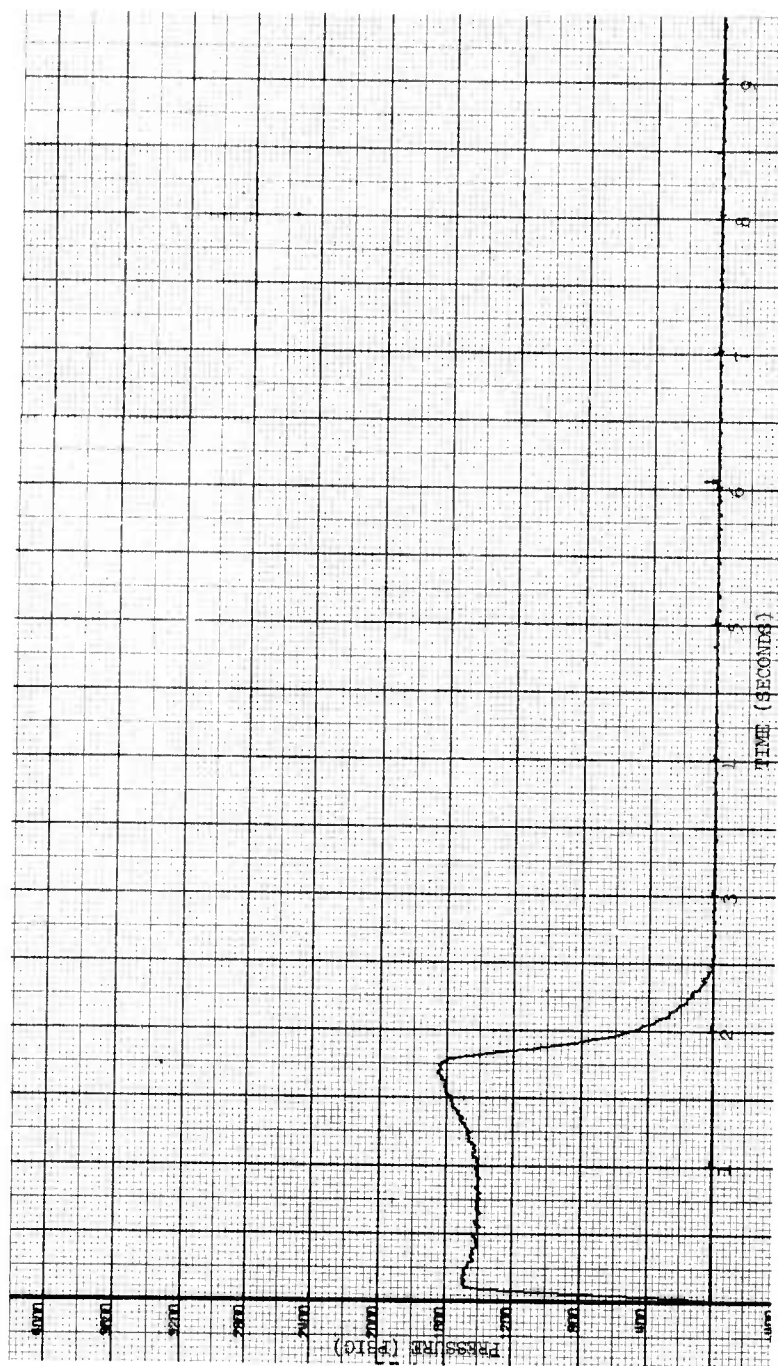


FIGURE E-1
SIDEWINDER MK 17 MOD 5 Motor Pressure
Test No. 2

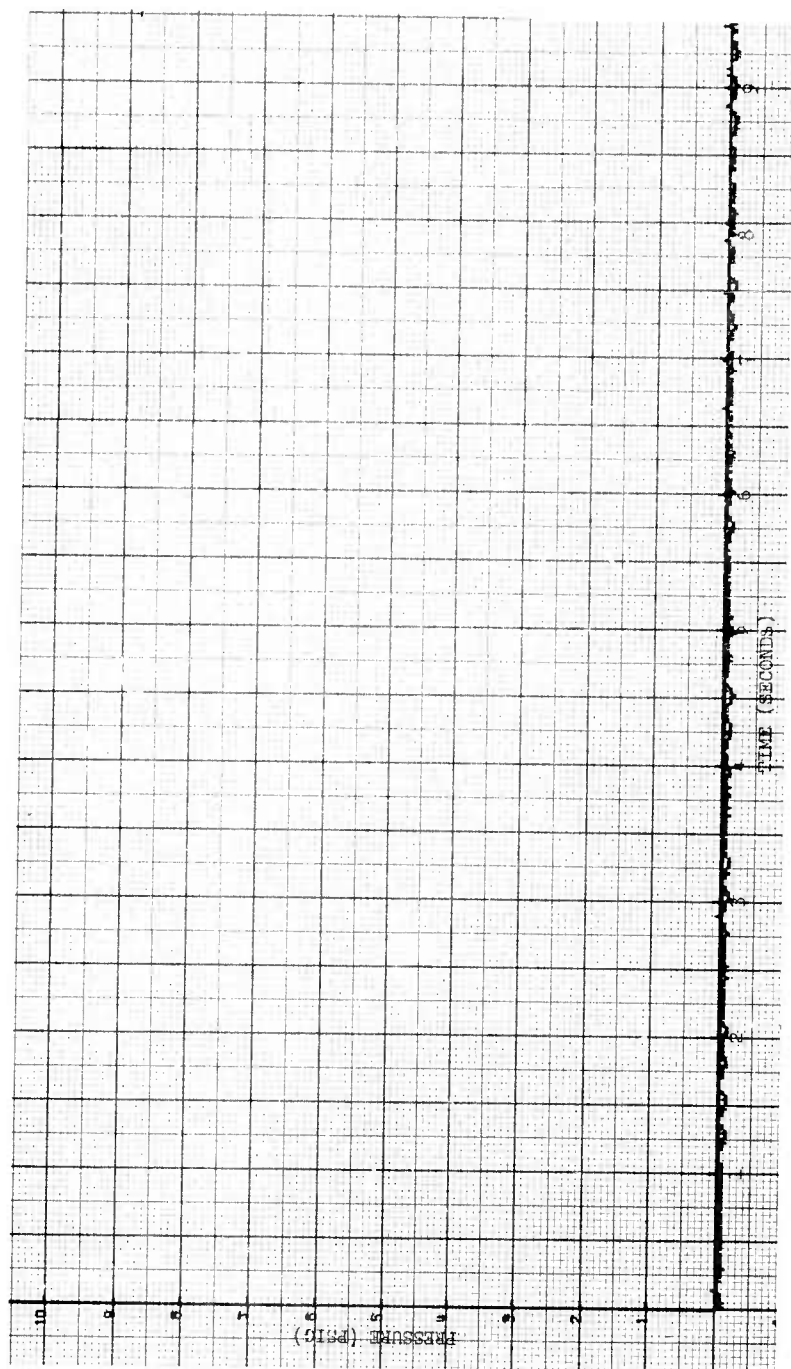


FIGURE E-2
Pressure Transducer No. 1
Test No. 2

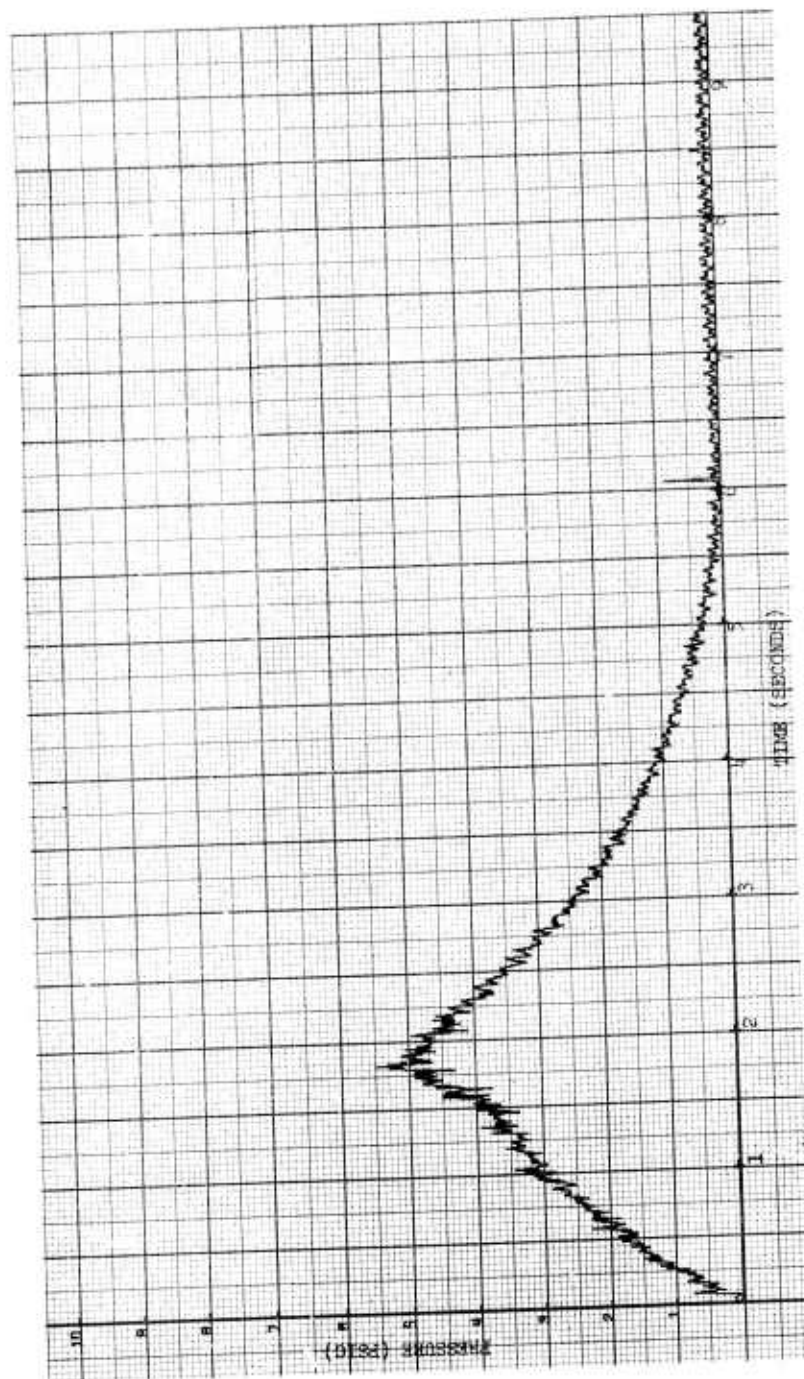


FIGURE E-3

Pressure Transducer No. 2
Test No. 2

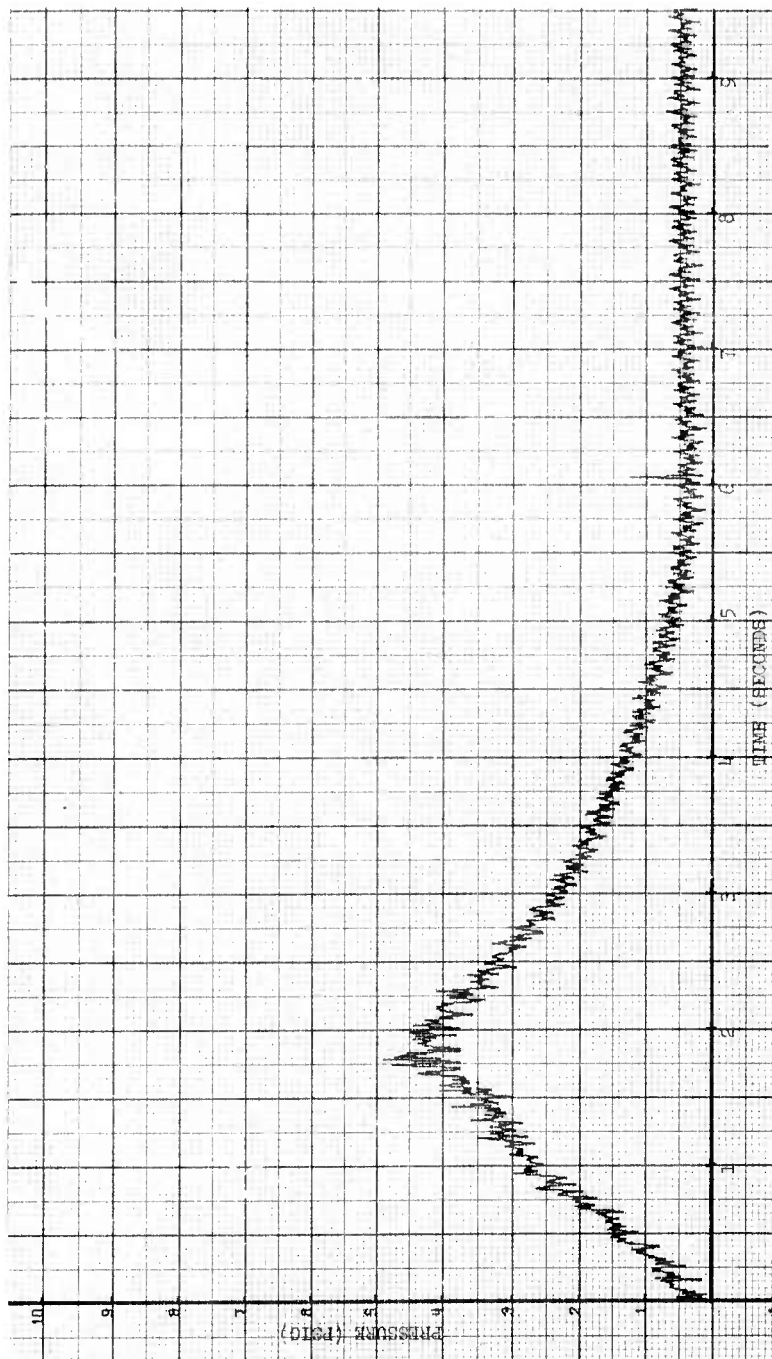


FIGURE E-4
Pressure Transducer No. 3
Test No. 2

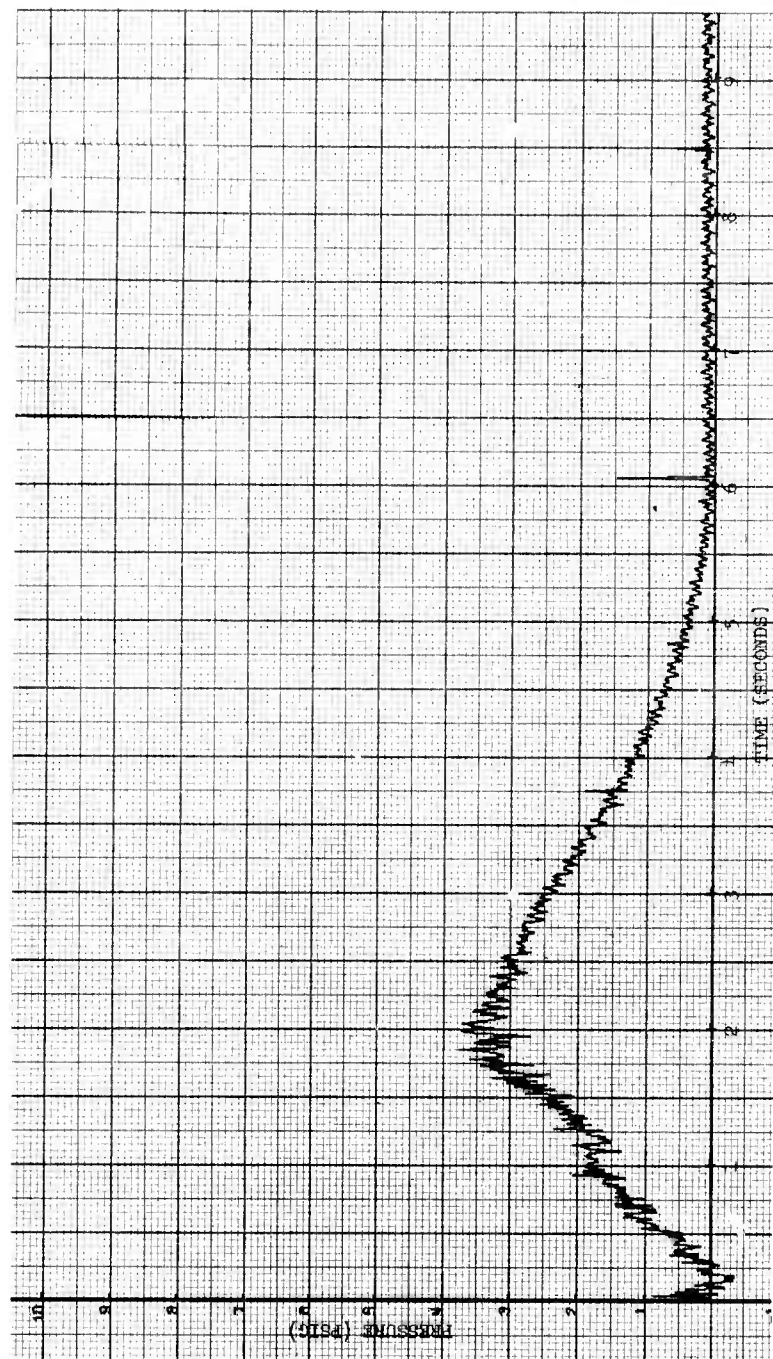


FIGURE E-5
Pressure Transducer No. 4
Test No. 2

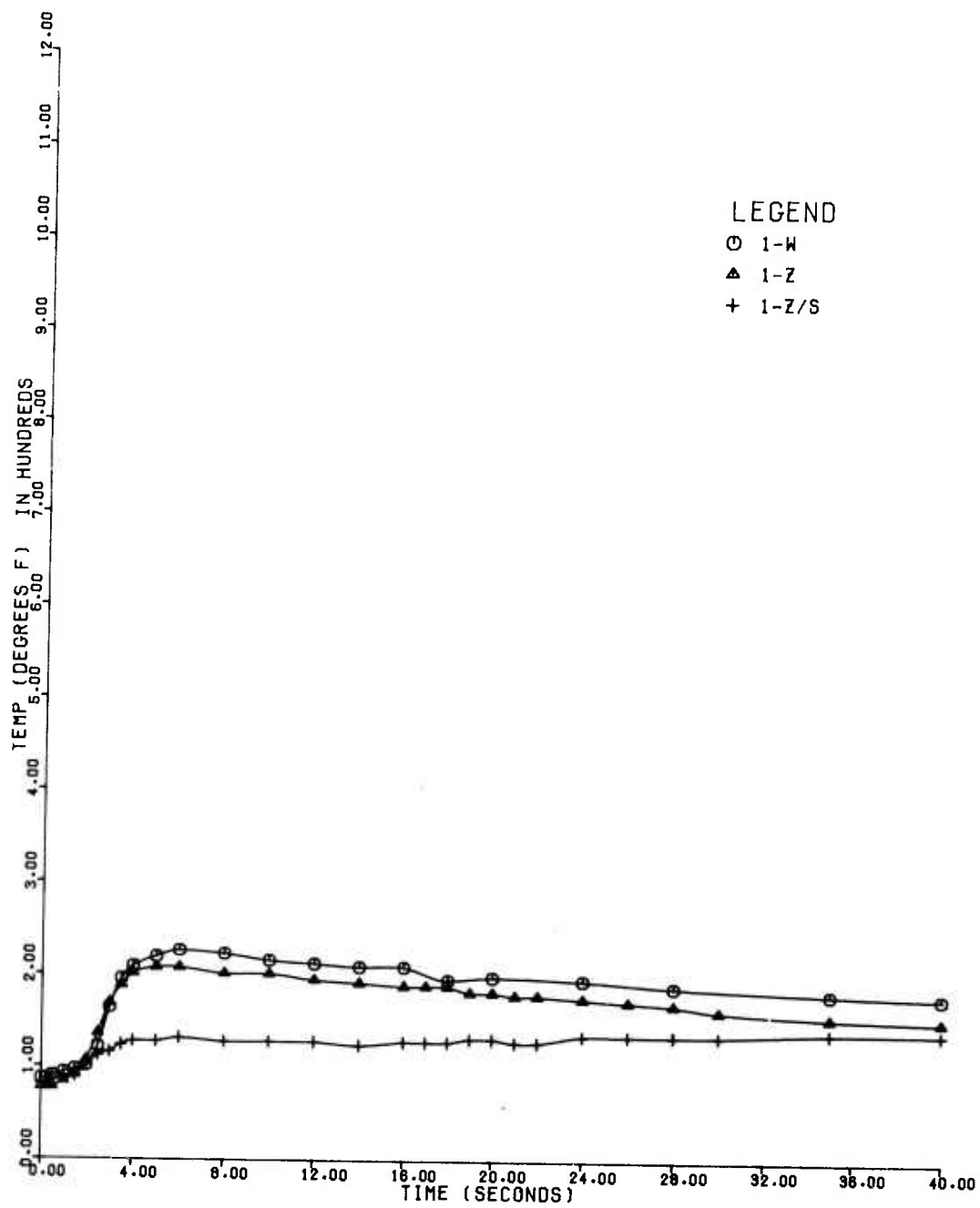


FIGURE E-6

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

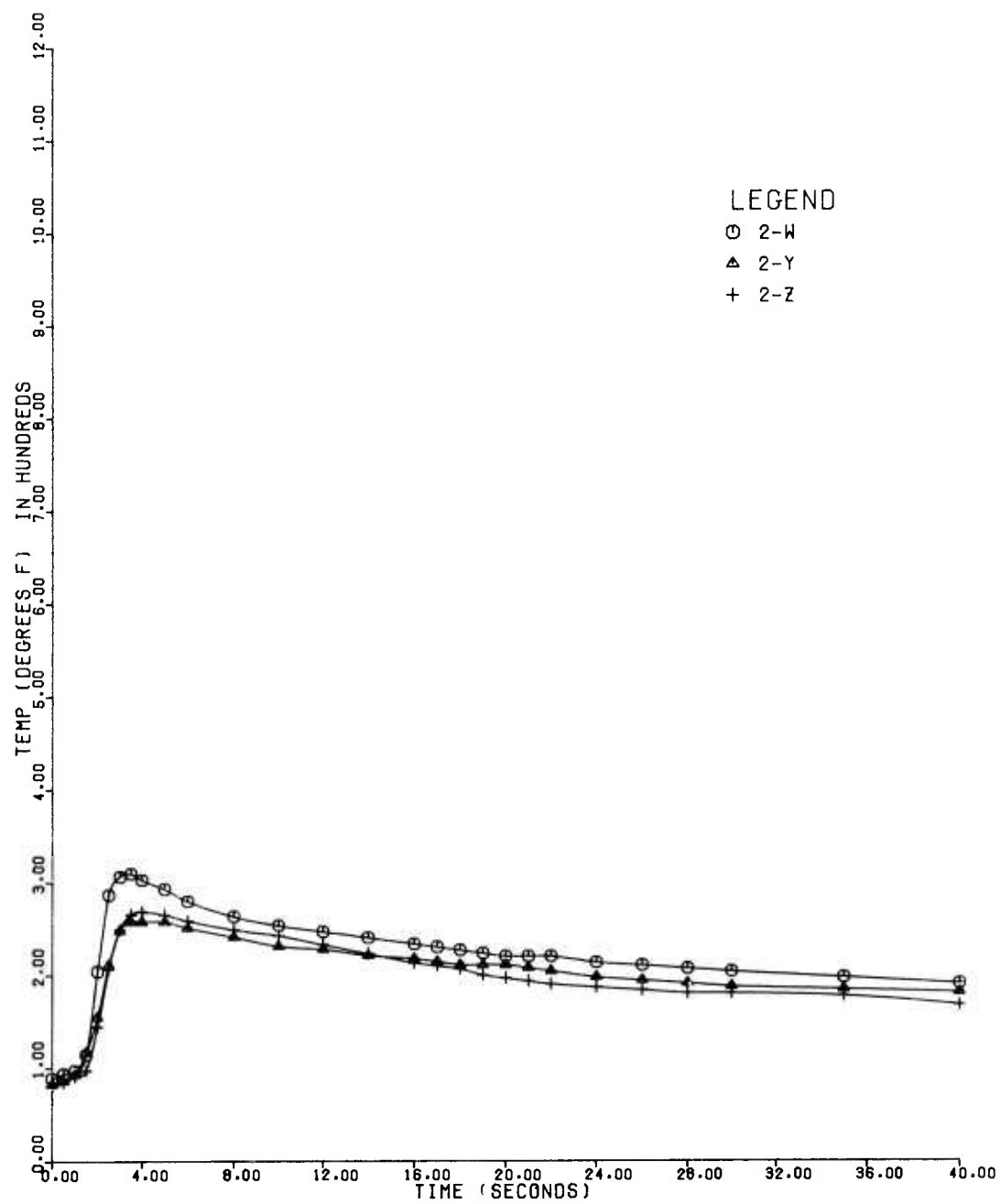


FIGURE E-7

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

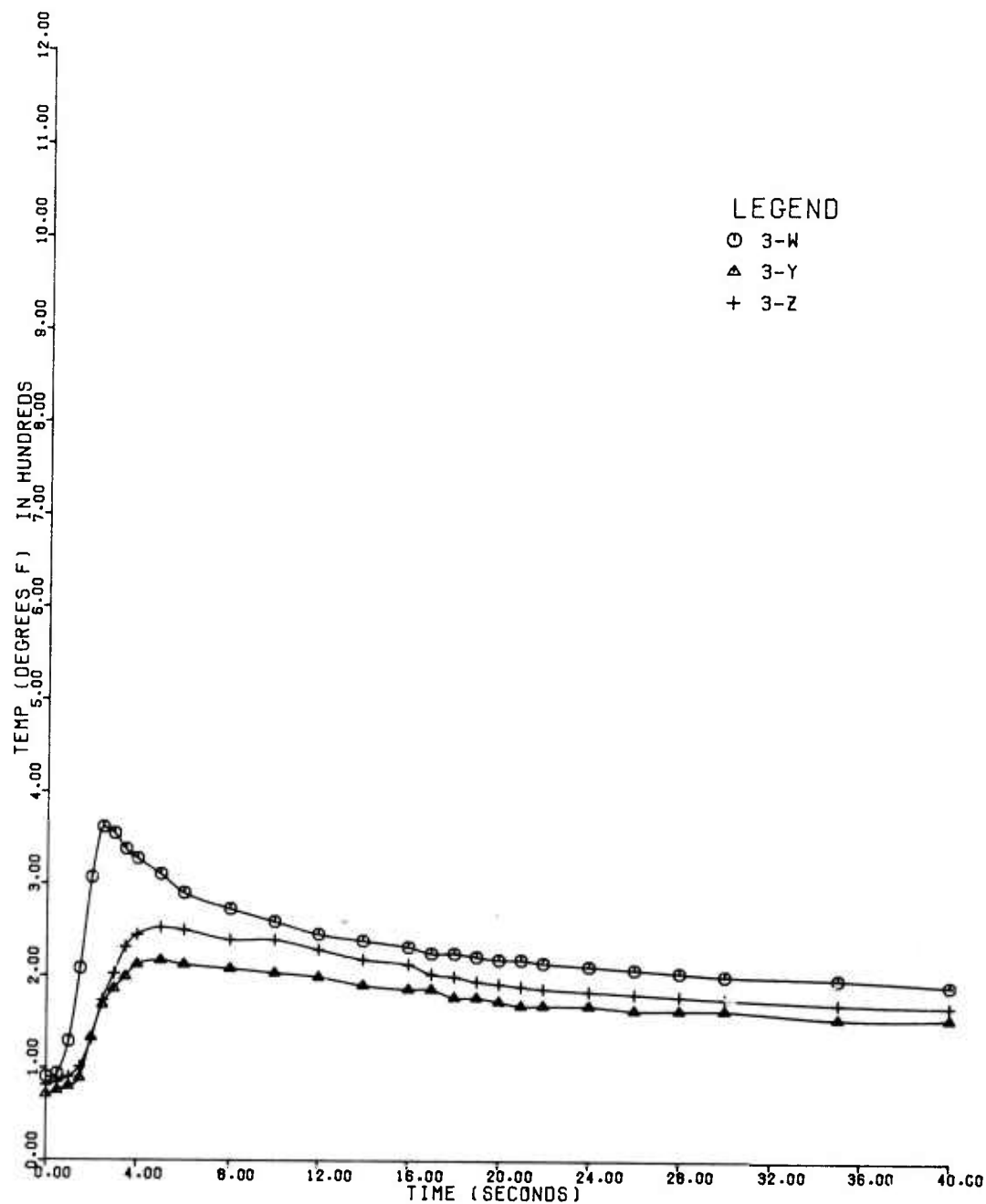


FIGURE E-8

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

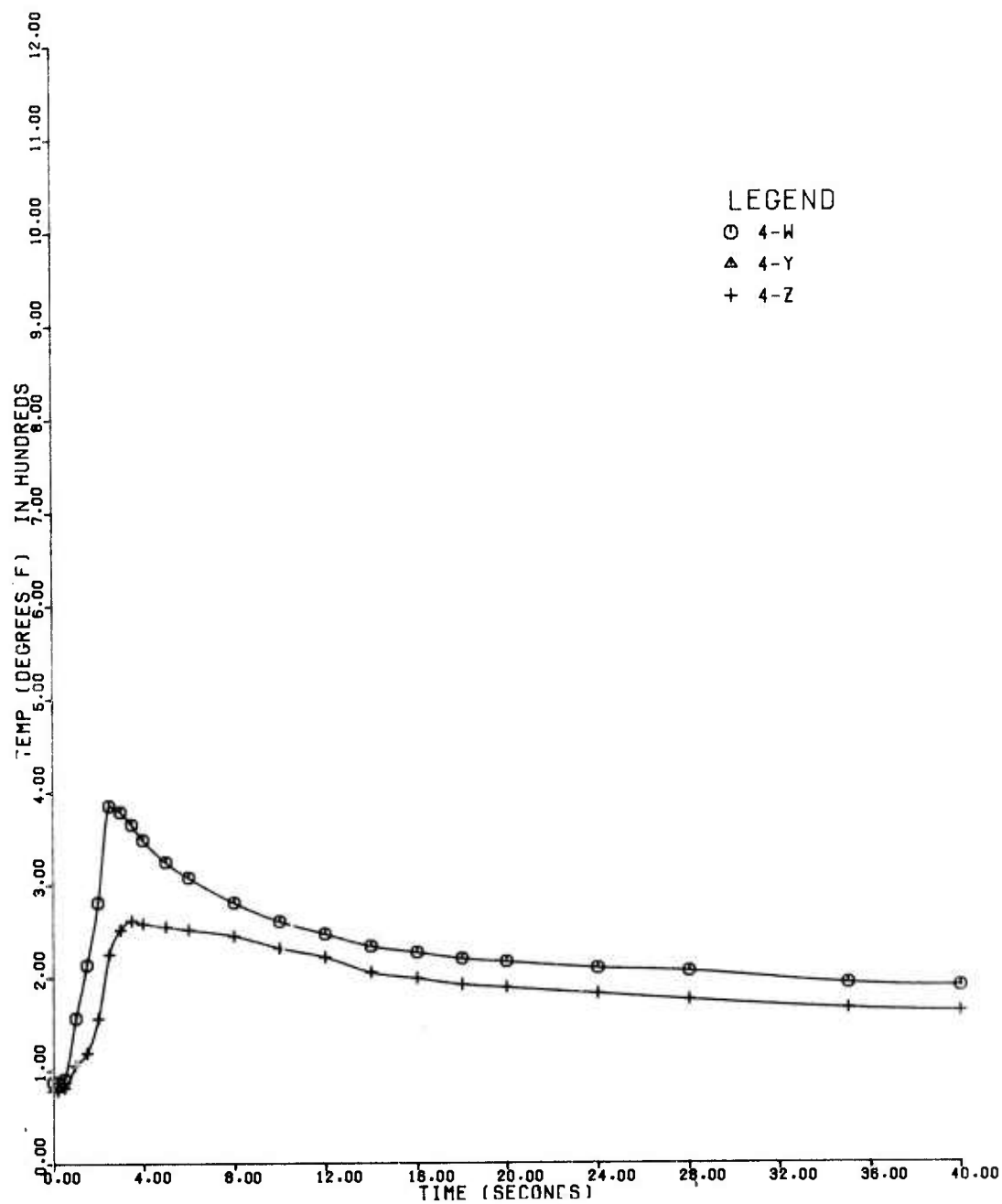


FIGURE E-9

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

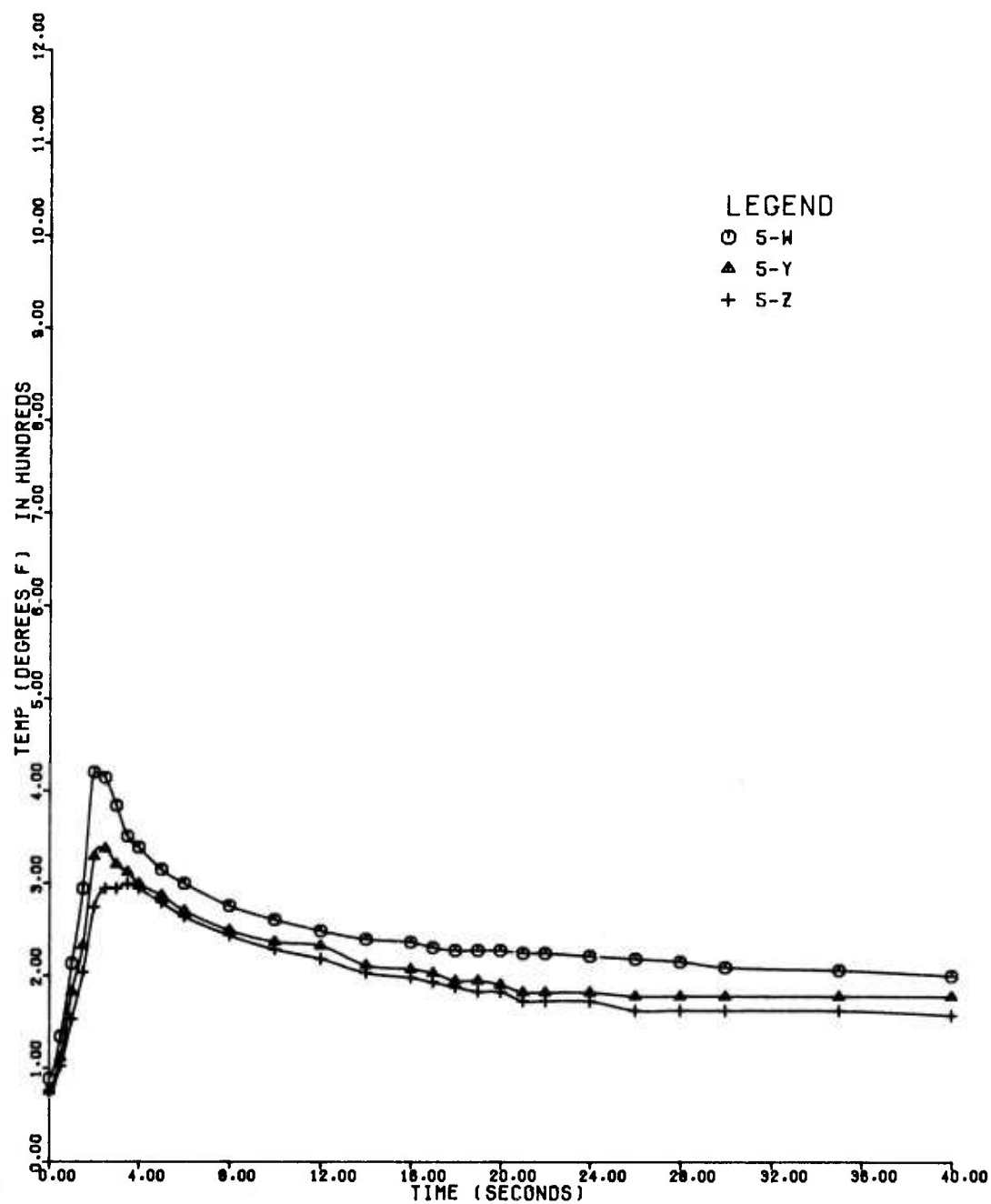


FIGURE E-10
Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

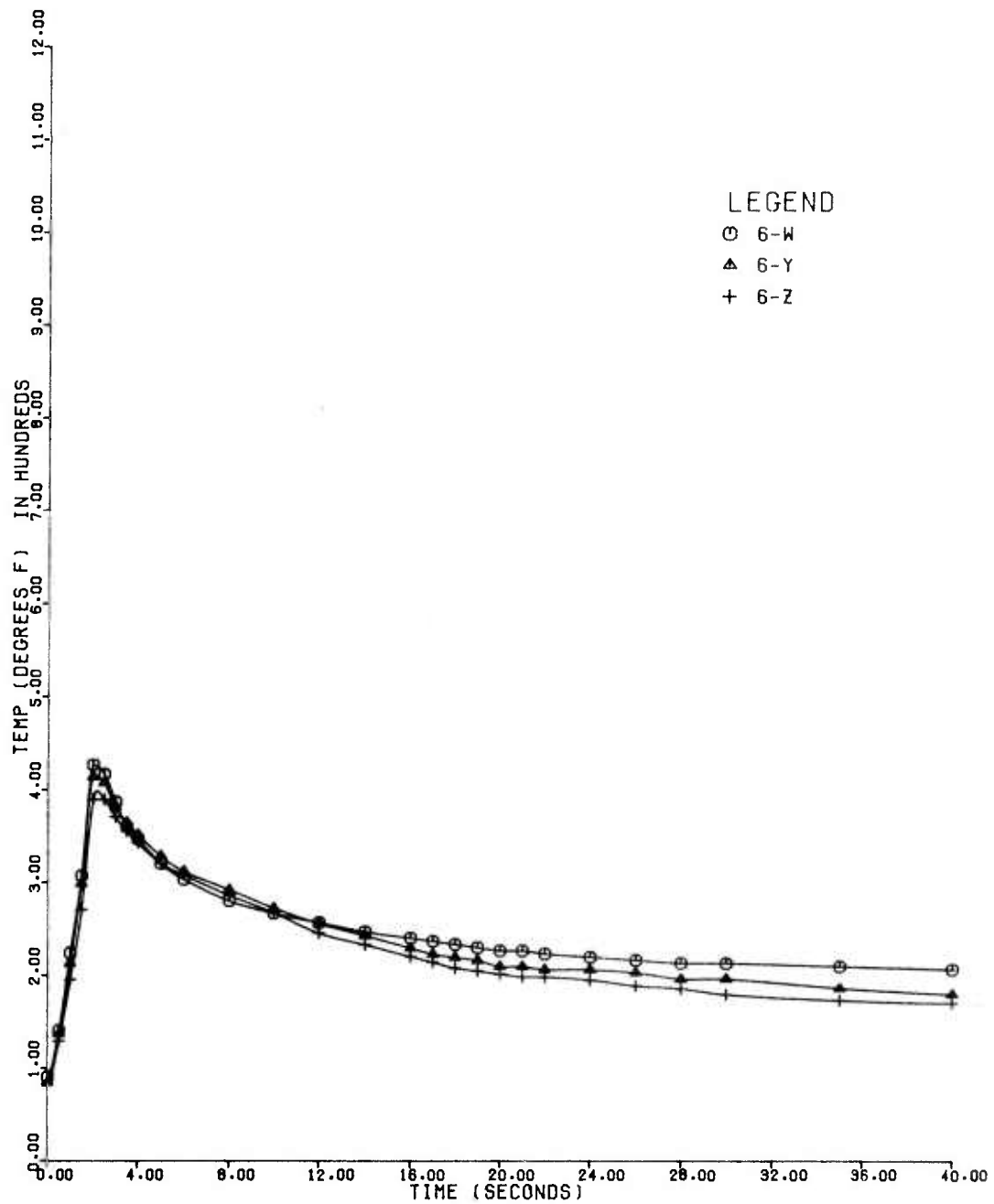


FIGURE E-11

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

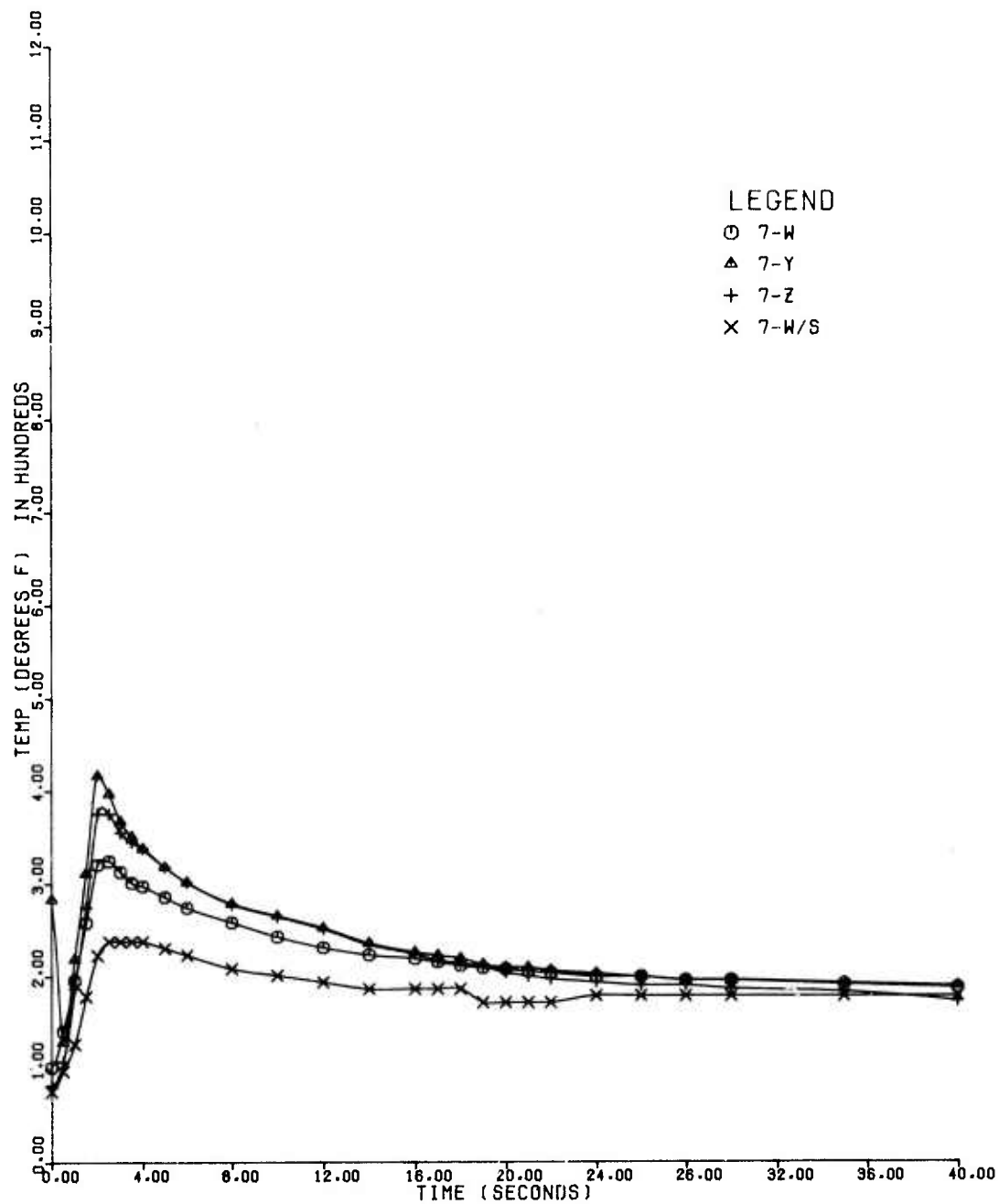


FIGURE E-12

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

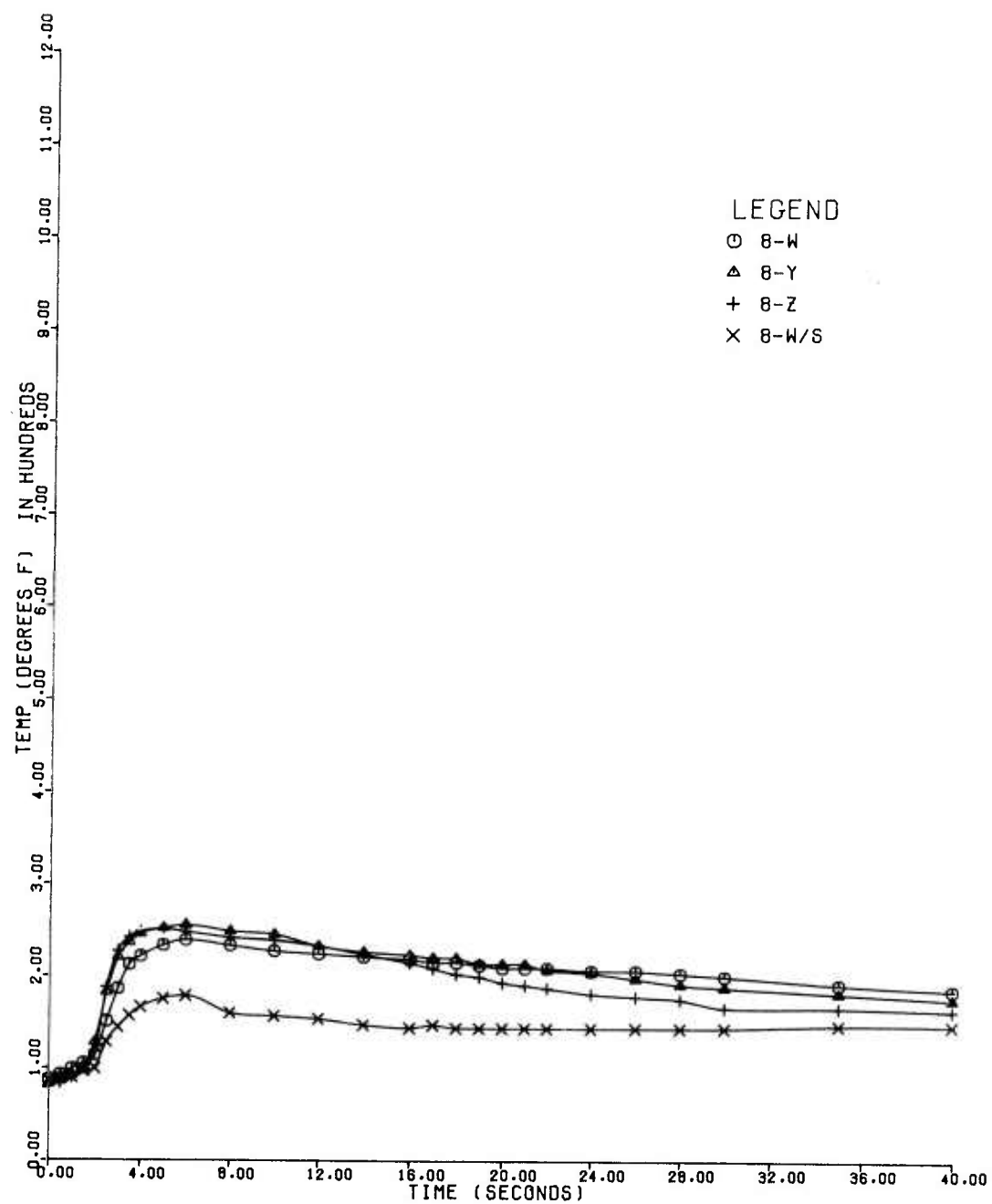


FIGURE E-13

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

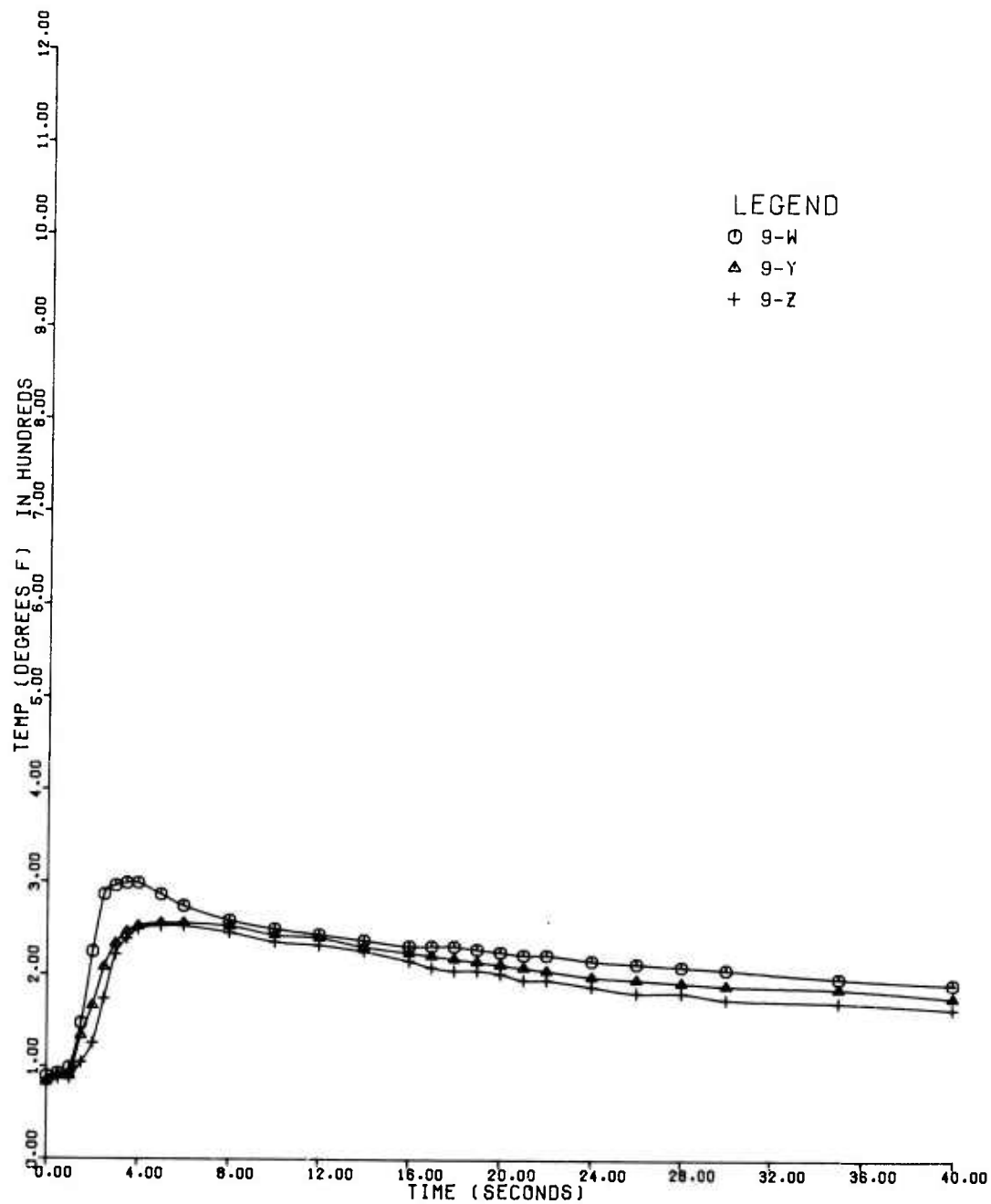


FIGURE E-14

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

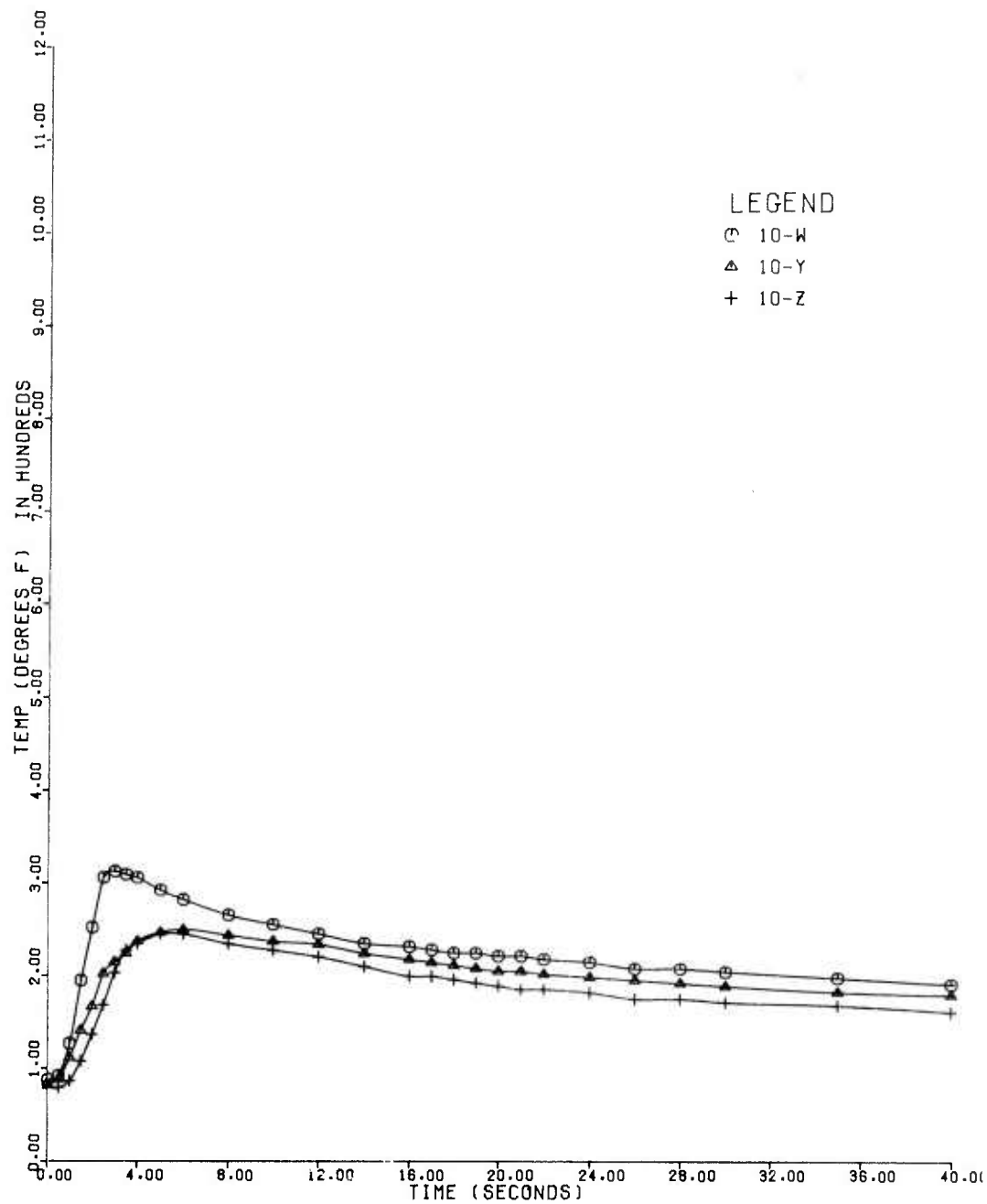


FIGURE E-15

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

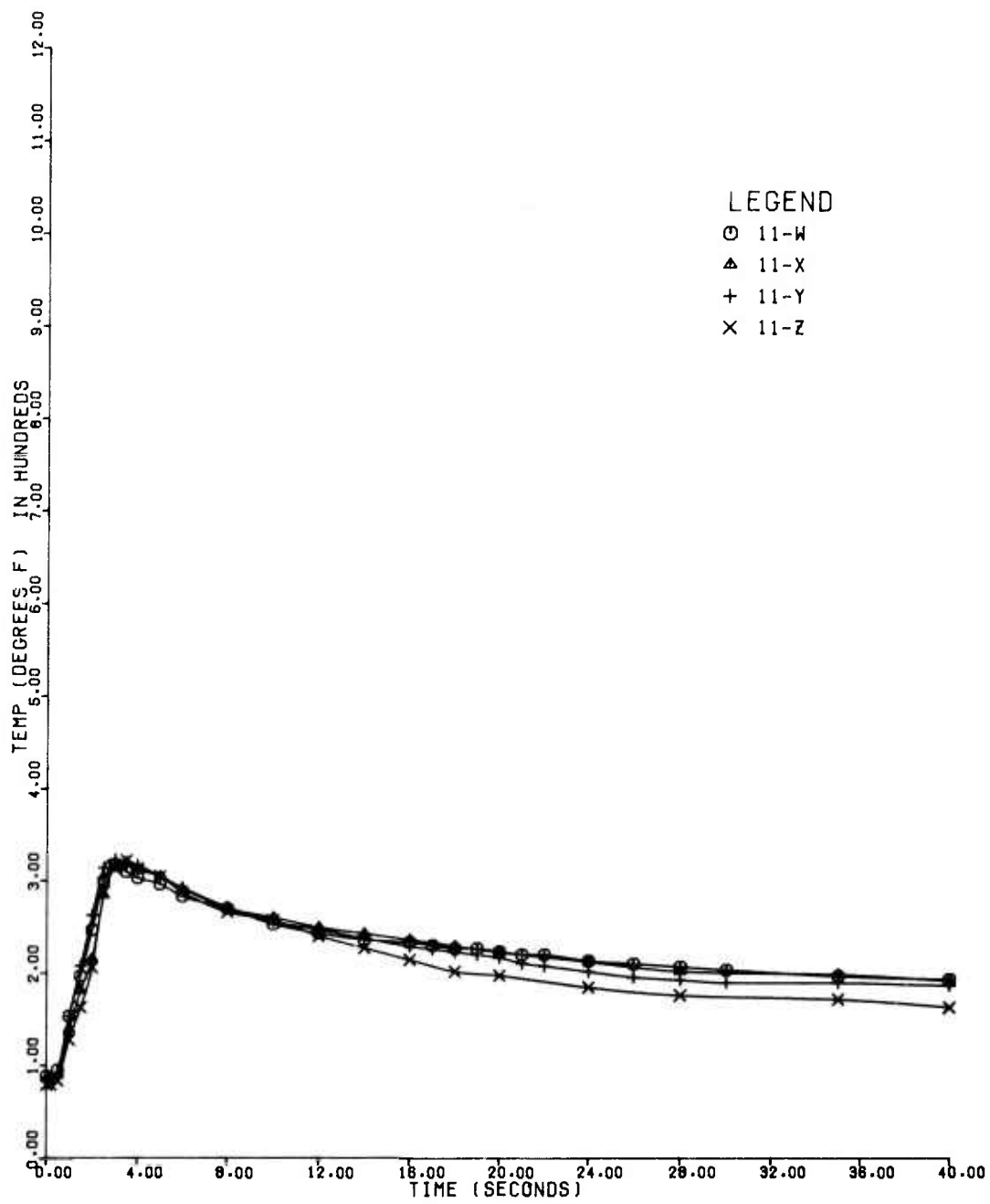


FIGURE E-16

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

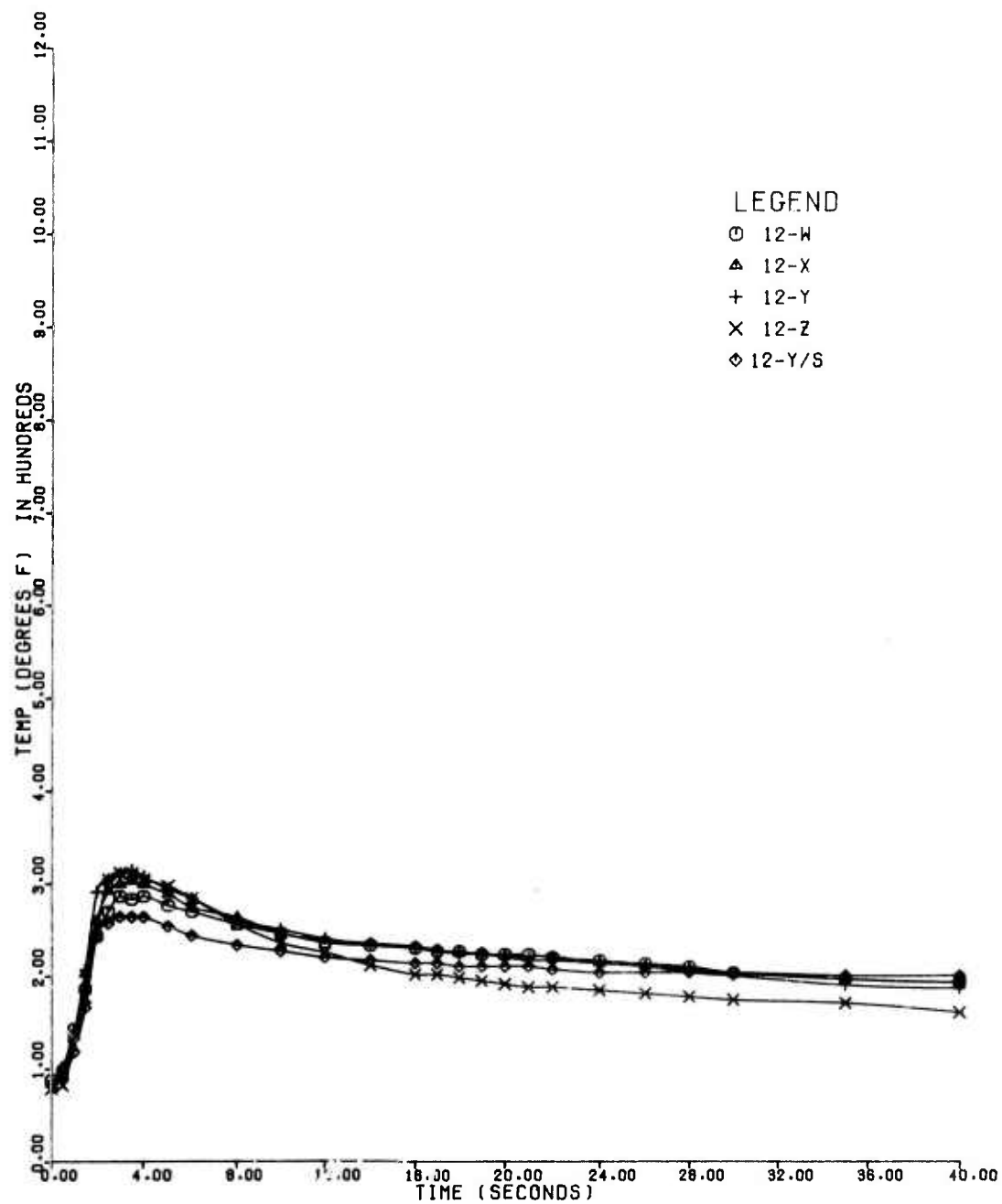


FIGURE E-17

Temperature-vs-Time
CV⁴ Magazine Test
No. 2 7 August 1973

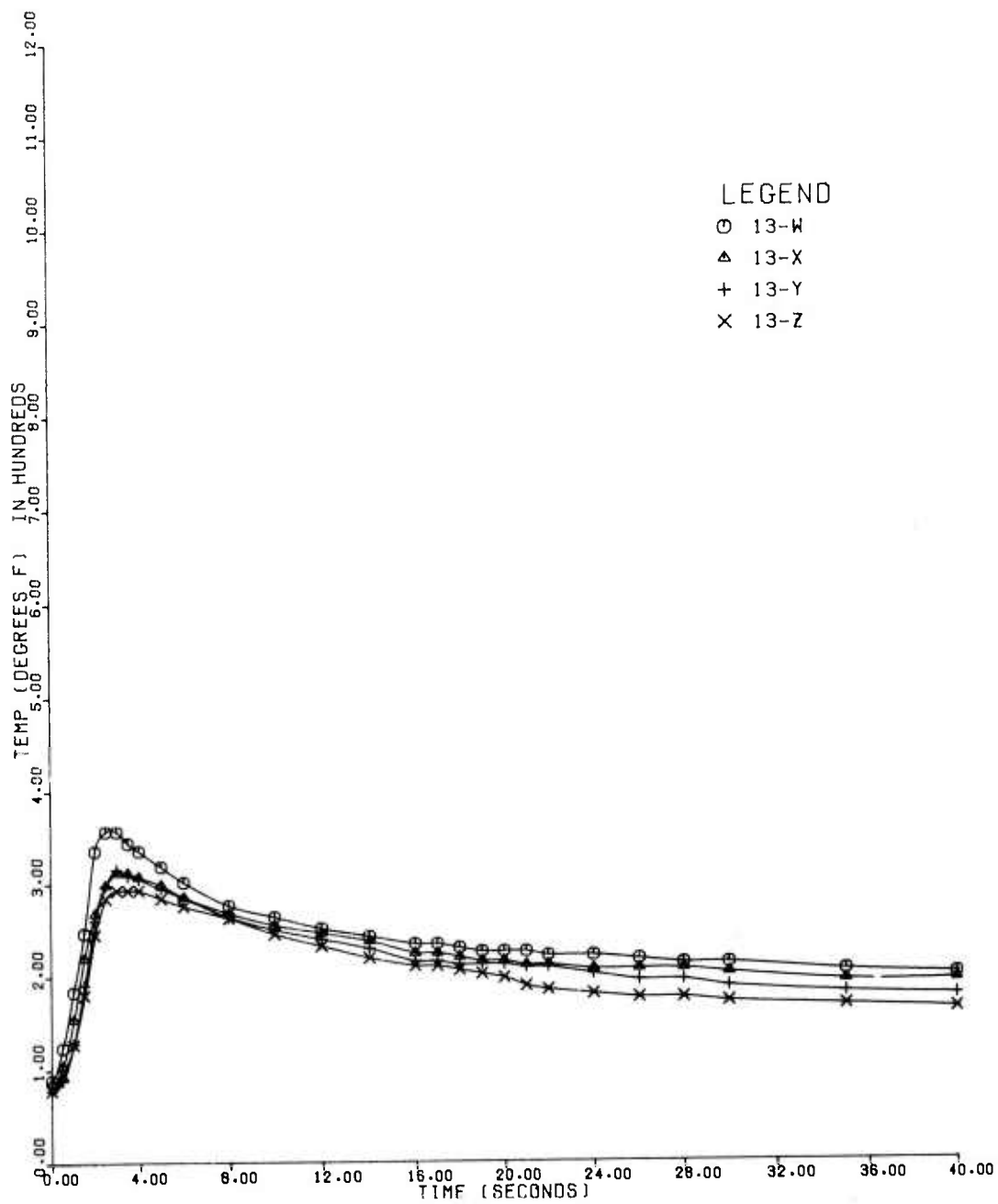


FIGURE E-18

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

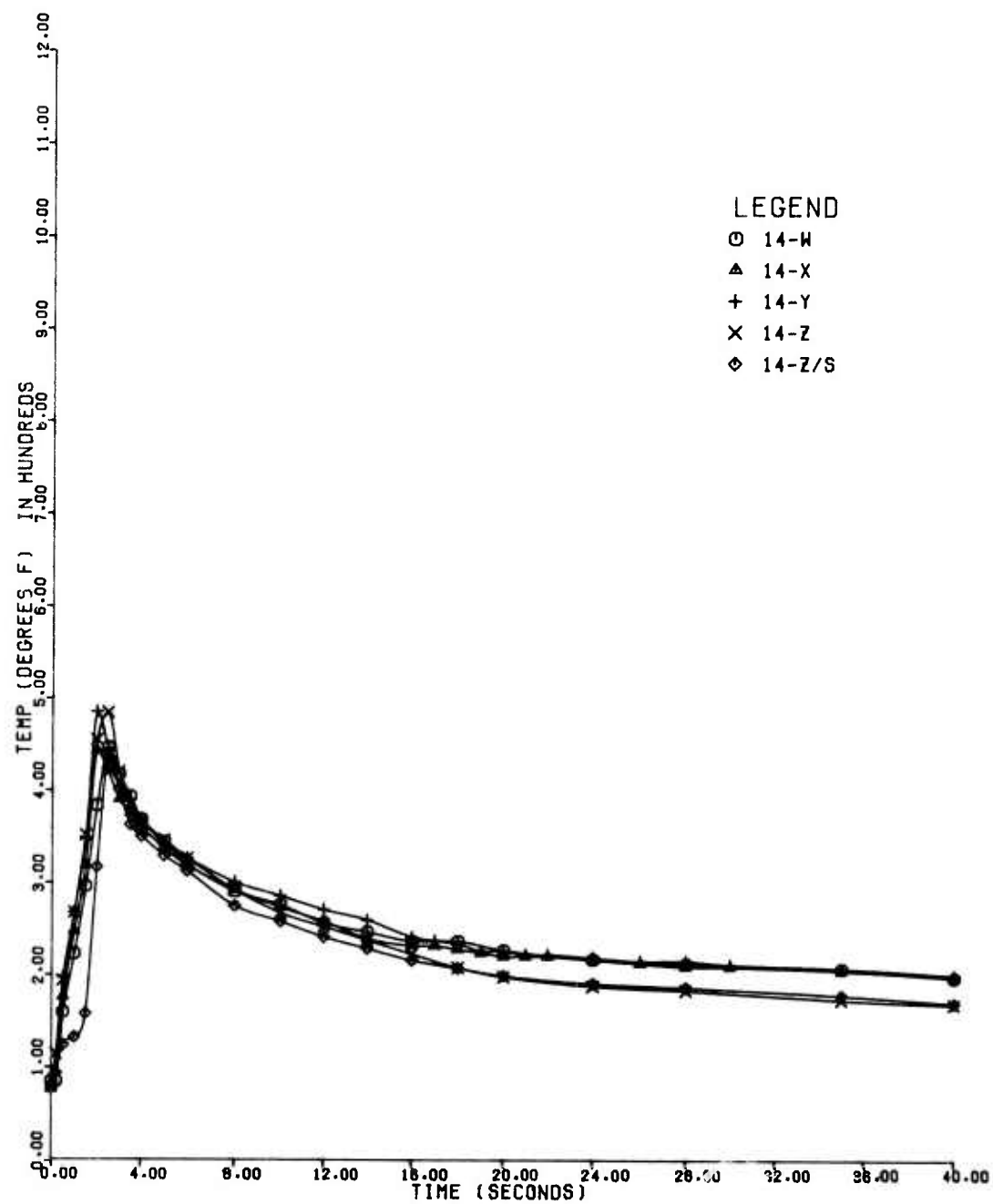


FIGURE E-19

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

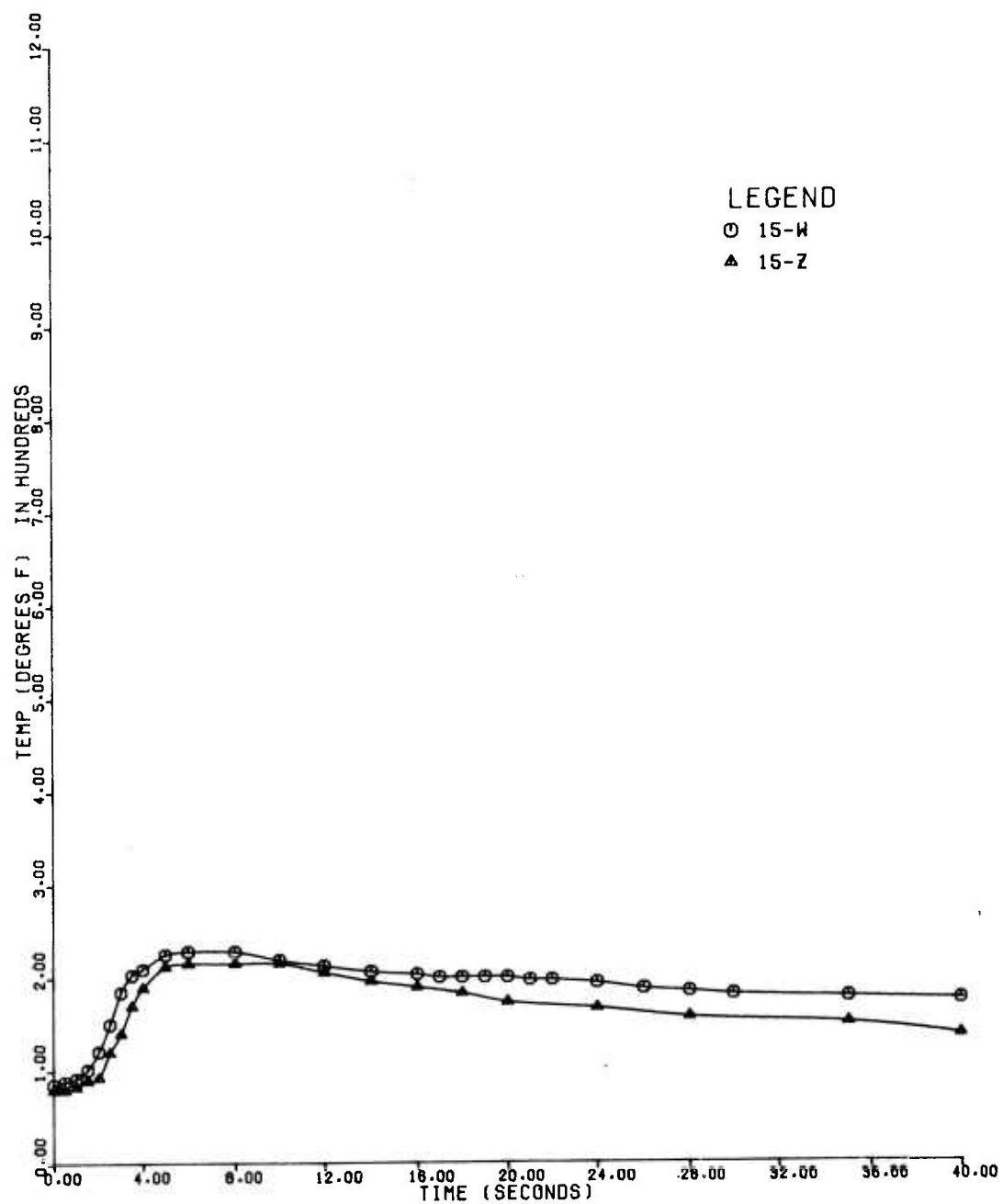


FIGURE E-20

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

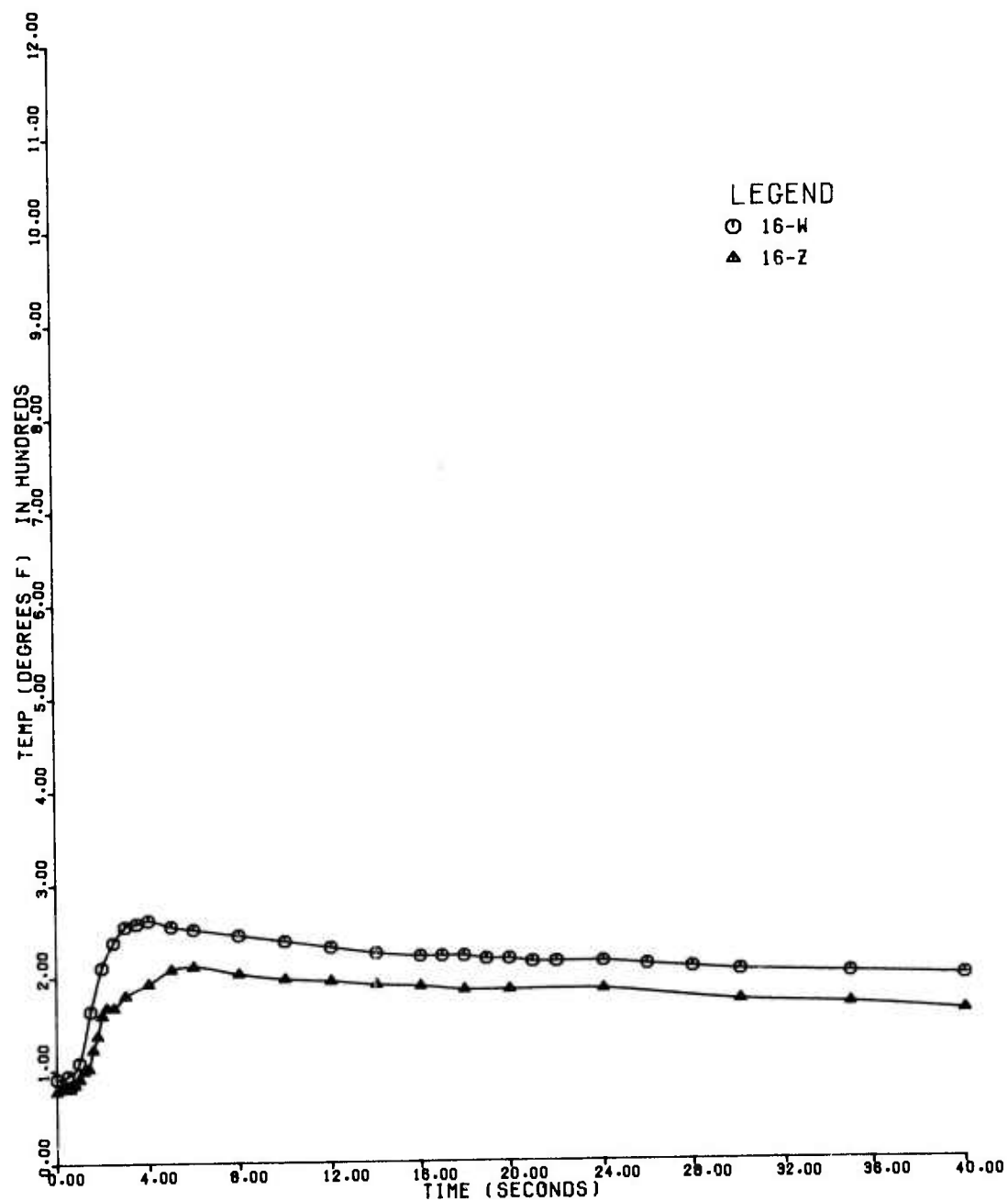


FIGURE E-21

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

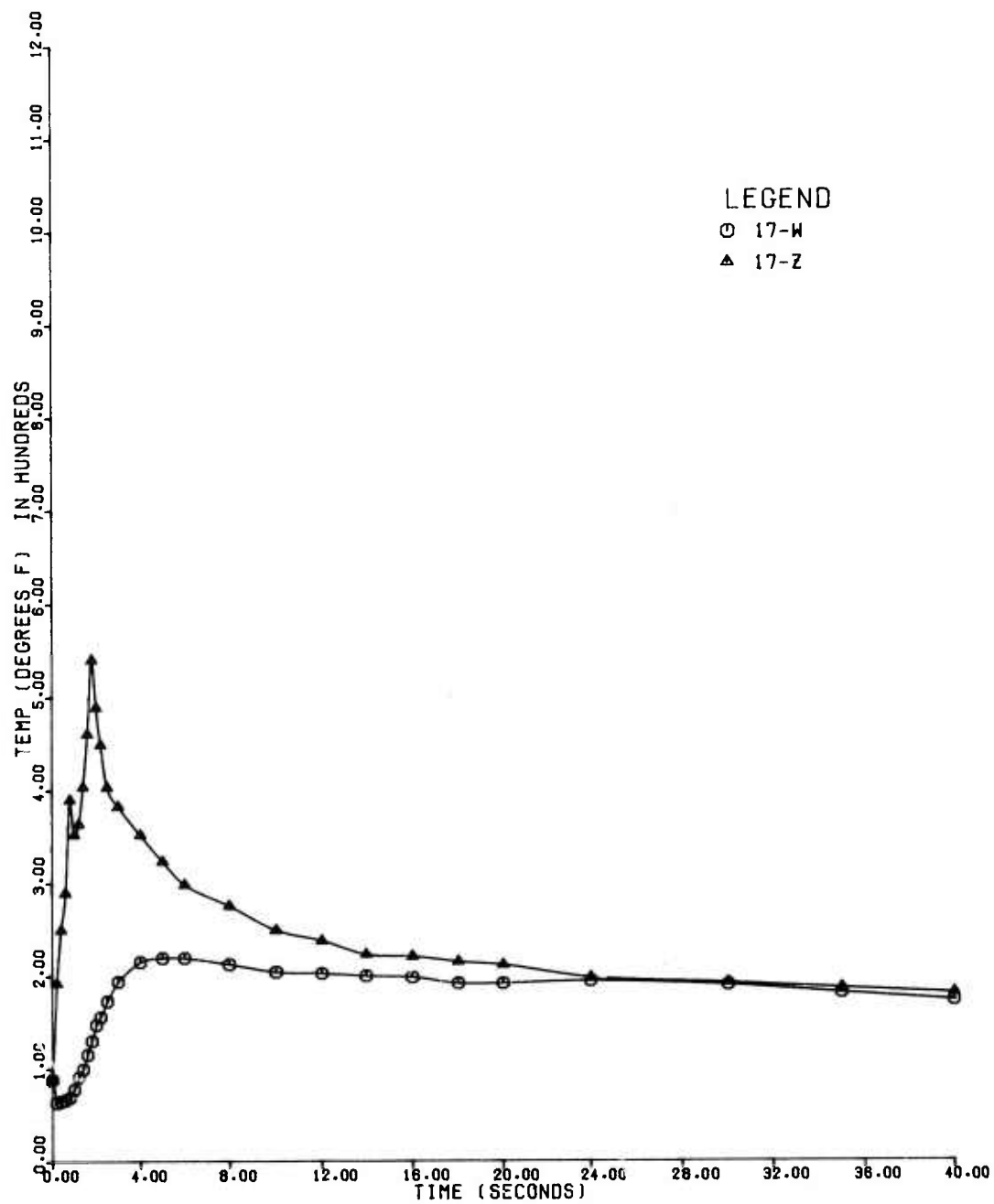


FIGURE E-22
Temperature-vs Time
CVA Magazine Test
No. 2 7 August 1973

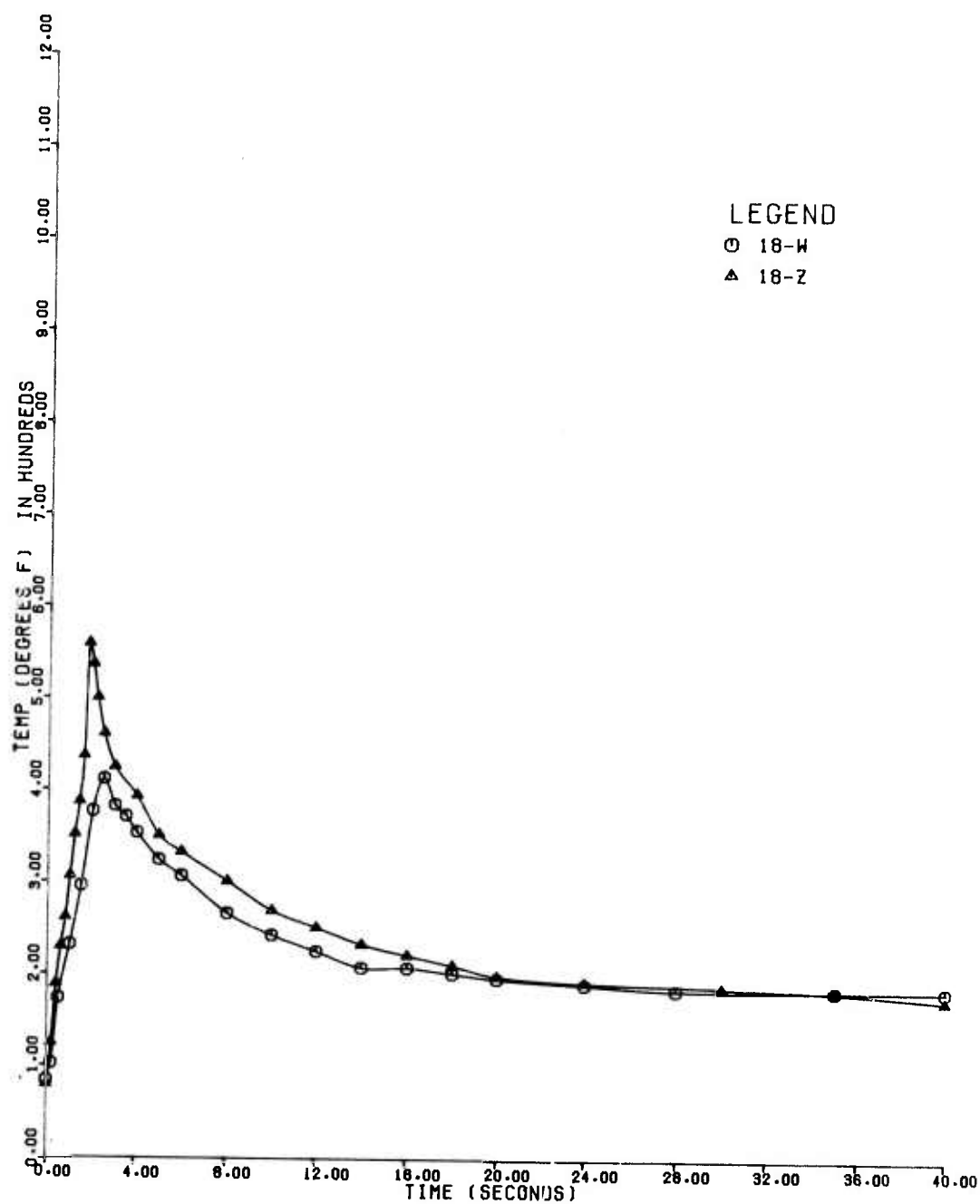


FIGURE E-23
Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

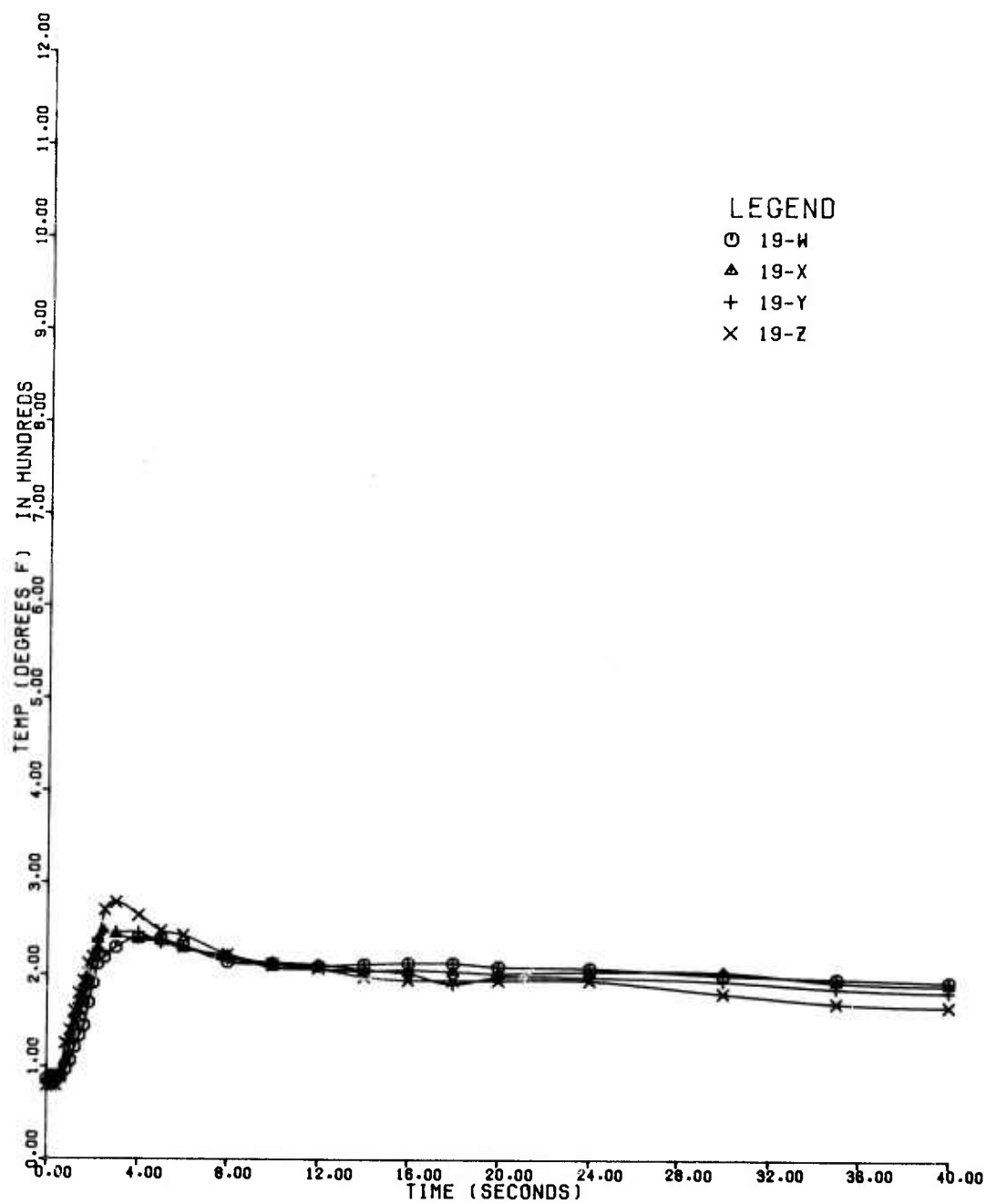


FIGURE E-24

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

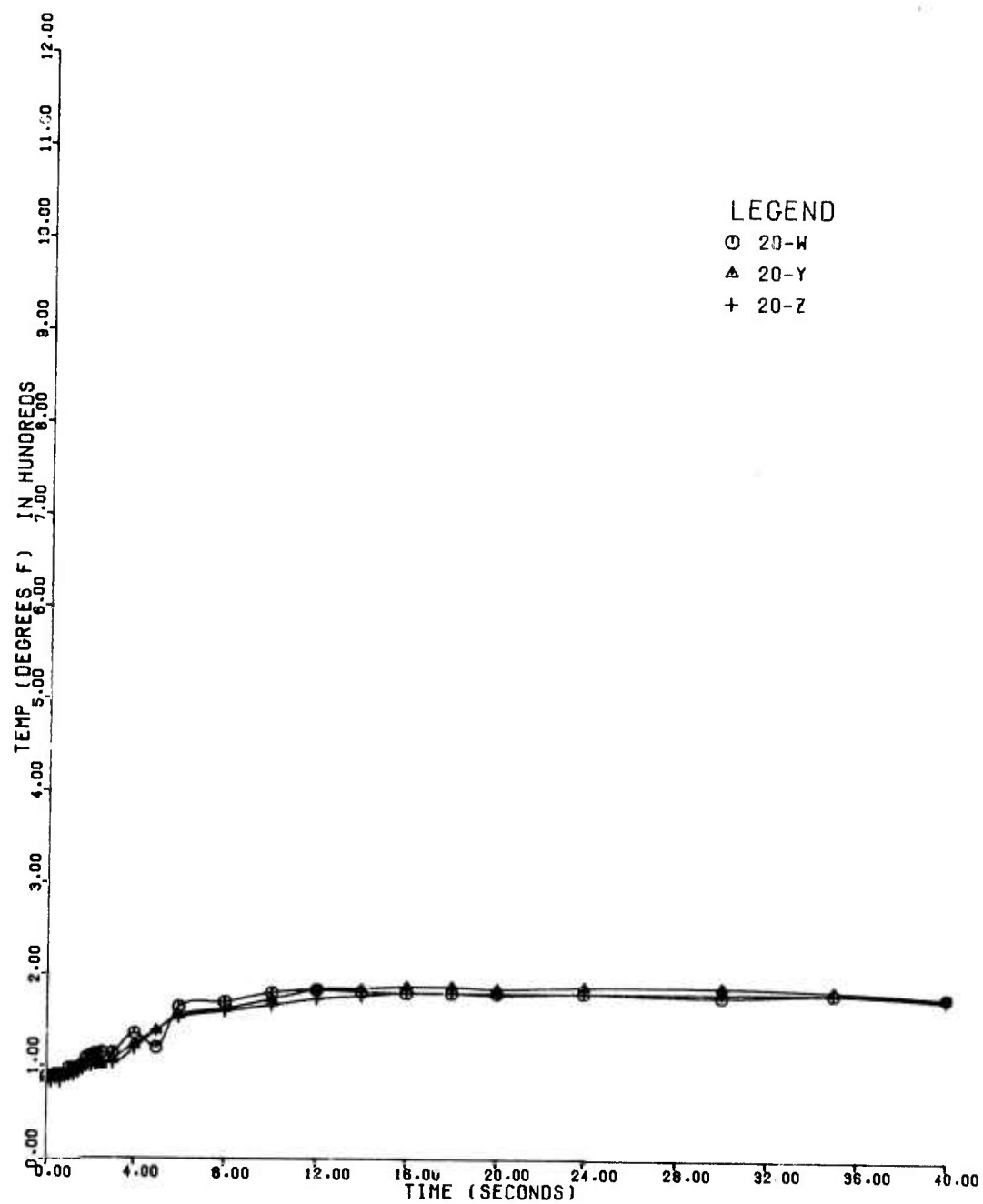


FIGURE E-25

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

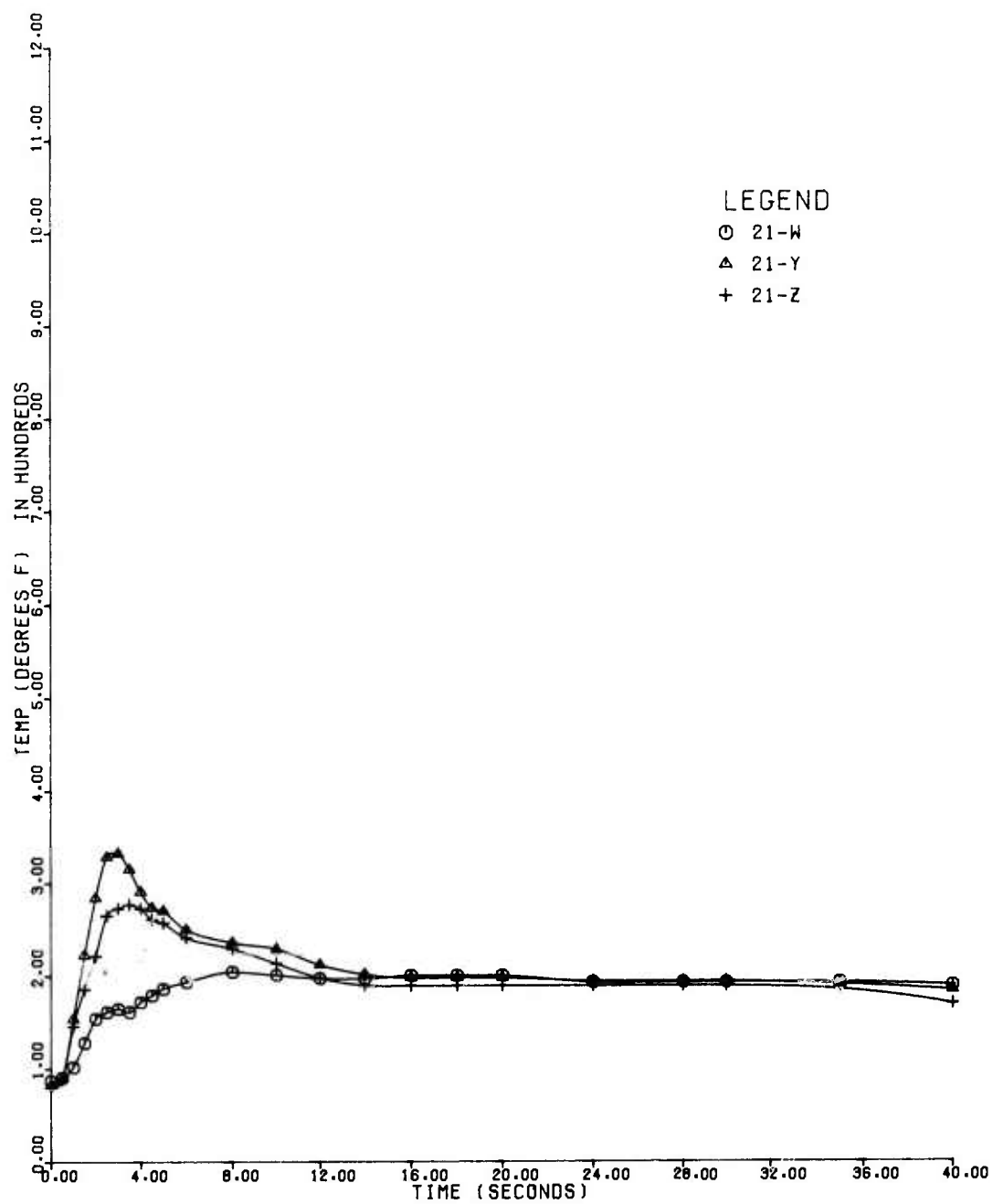


FIGURE E-26

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

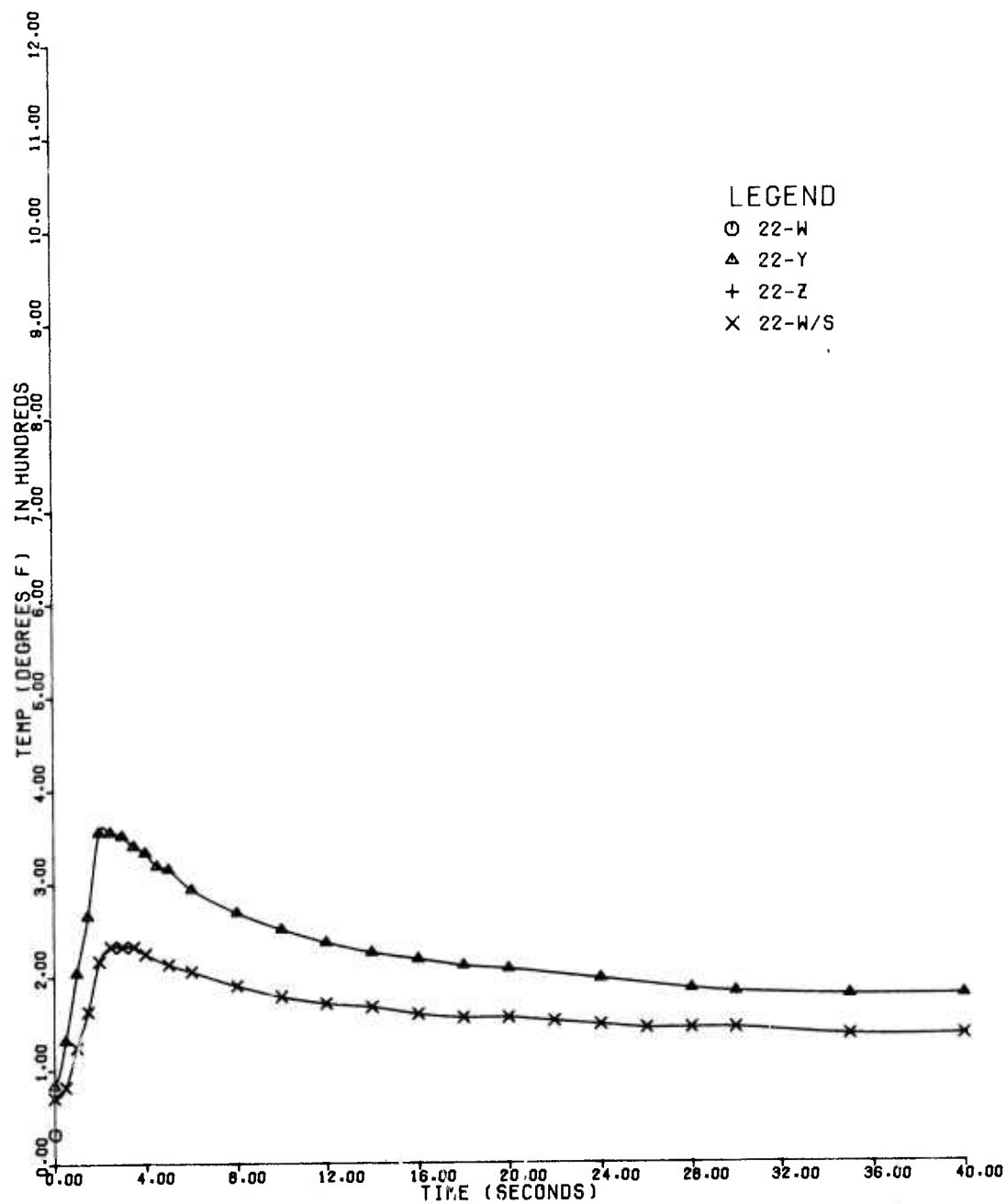


FIGURE E-27

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

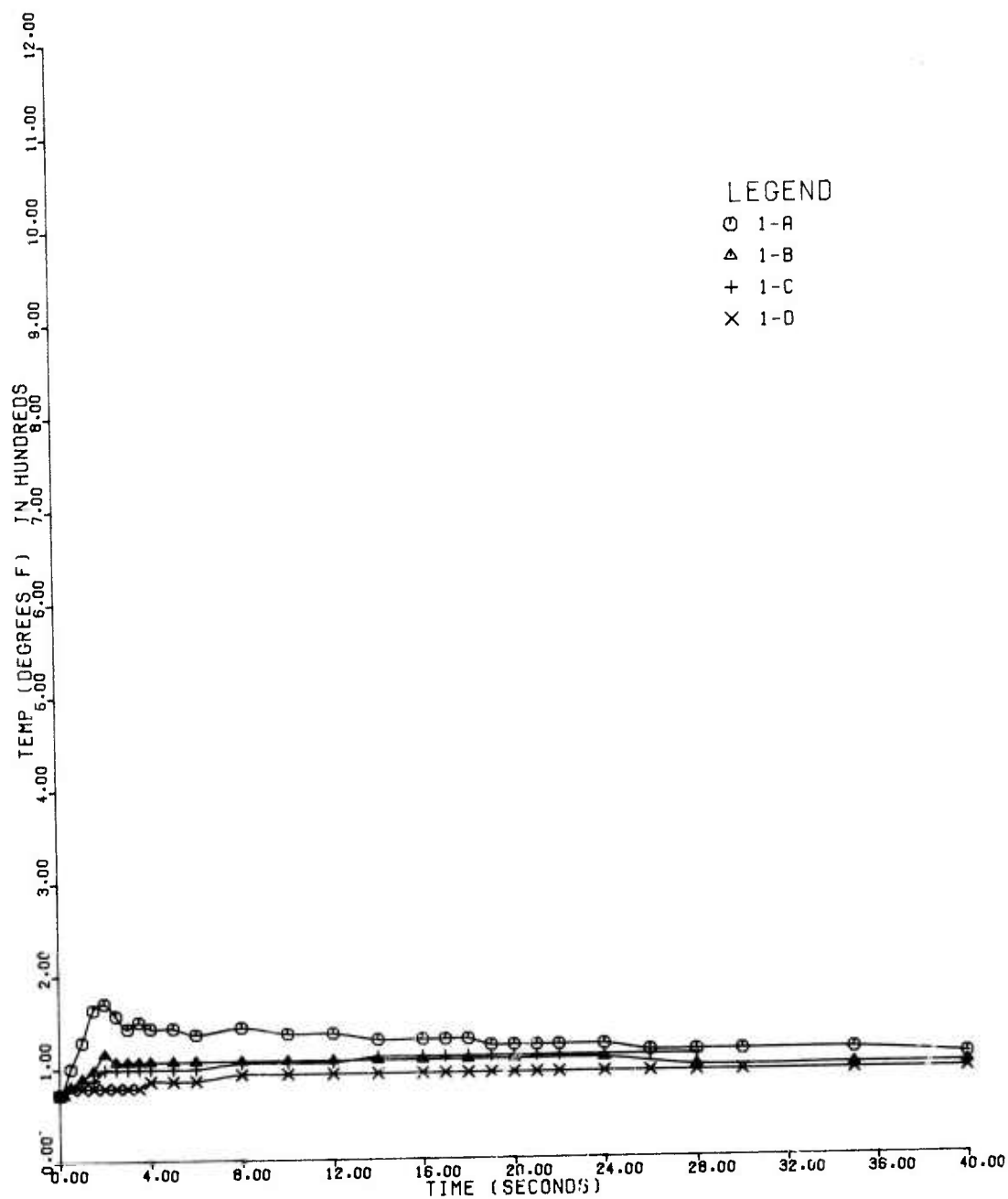


FIGURE E-28

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

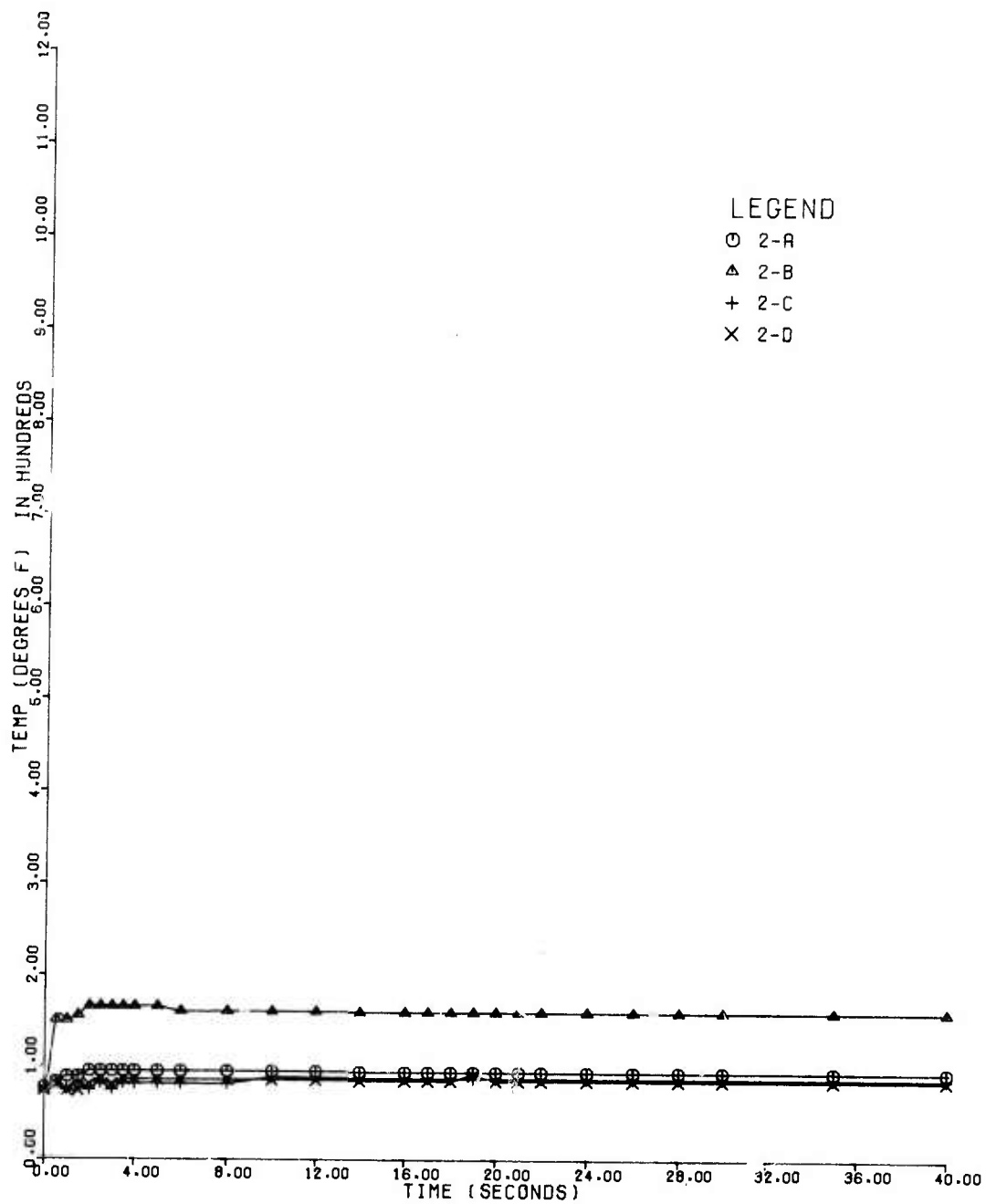


FIGURE E-29

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

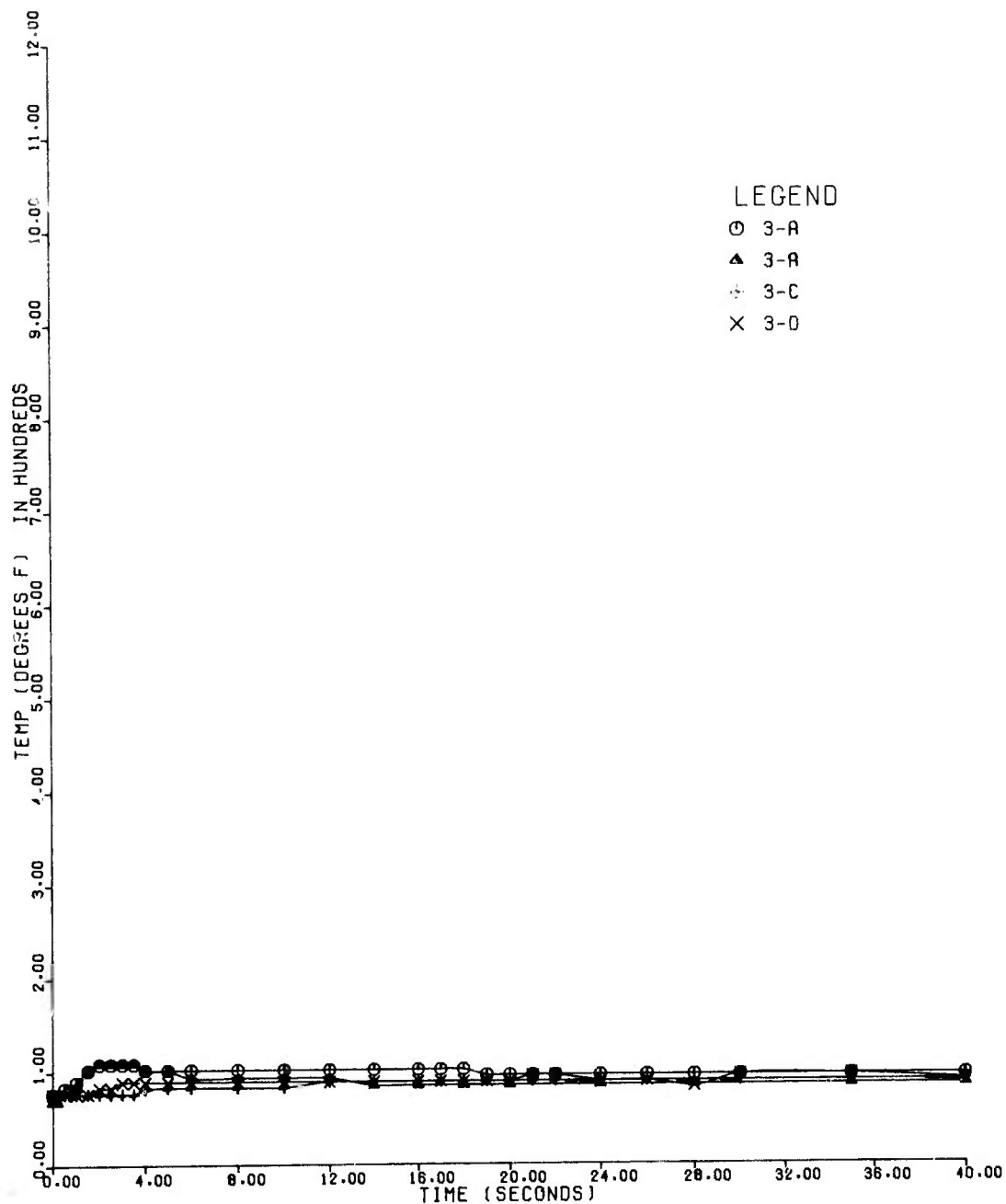


FIGURE E-30

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

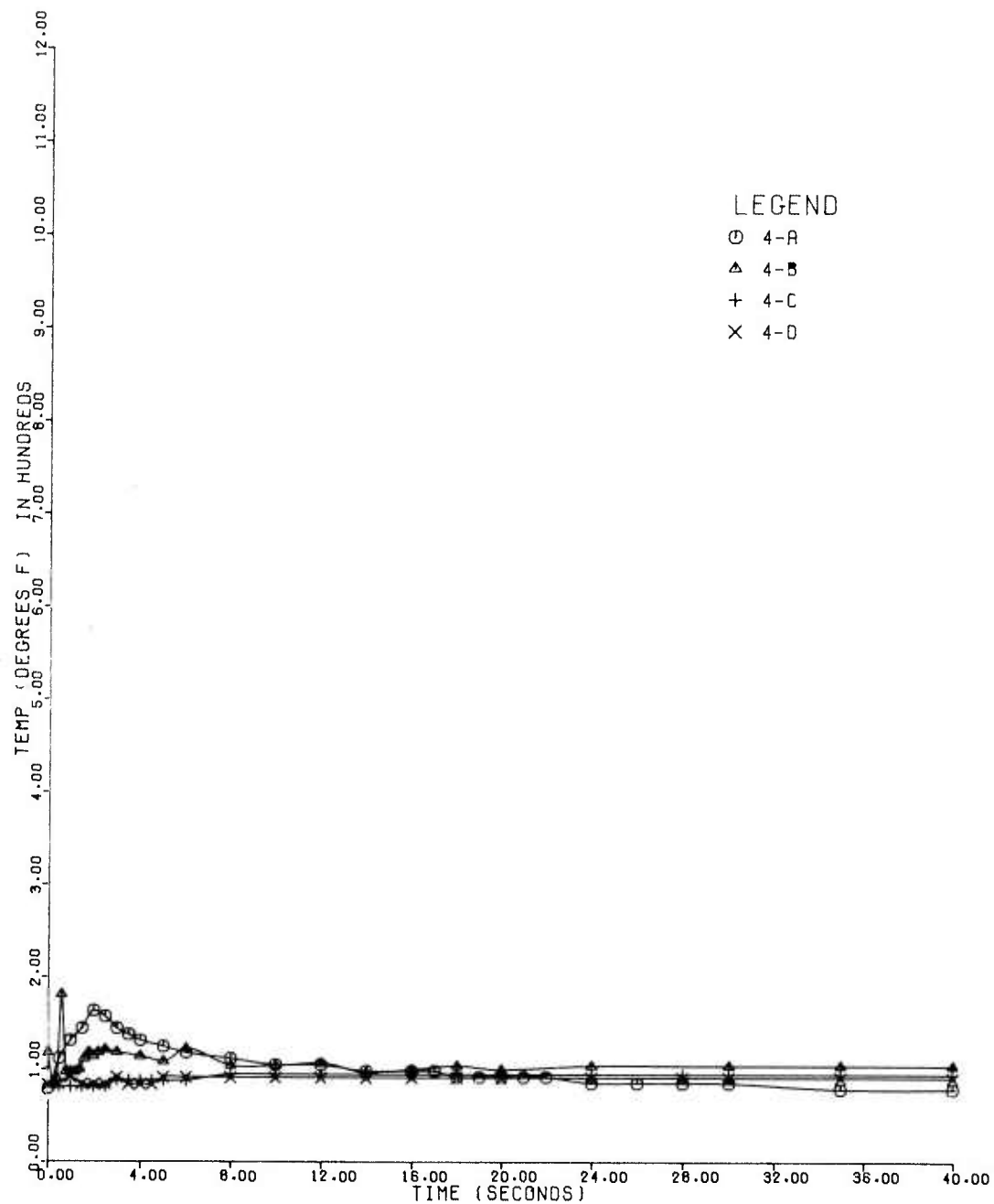


FIGURE E-31

Temperature-vs-Time
CVA Magazine Test
No. 2 7 August 1973

APPENDIX F
DISTRIBUTION

DISTRIBUTION

Commander
Naval Sea Systems Command
Washington, D. C. 20360
Attn: Code SEA 09B4
Code SEA 035B
Code SEA 0492
Code SEA 954
Code PMS 392

Commander
Naval Material Command
Washington, D. C. 20360
Attn: Code MAT OOF

Commander
Naval Air Systems Command
Washington, D. C. 20360
Attn: Code 09E

Commander
Naval Ship Engineering Center
Hyattsville, Maryland 20782
Attn: Code 6105
Code 6140C
Code 6154F
Code 6161D

Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314

(2)

Local:

D
E
ES
EST (50)
ESR (5)
EAD

GB
TFB (3)
TFE
MIL (2)
MIP-2
MIP-3 (5)
MIM

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|-----------------------|--|
| 1. REPORT NUMBER | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| TR-3139 | | |
| 4. TITLE (and Subtitle) | | 5. TYPE OF REPORT & PERIOD COVERED |
| TEMPERATURE AND PRESSURE PROFILES OBTAINED DURING BURN OF A SIDEWINDER MK 17 MOD 5 MOTOR IN A 15,300 CUBIC-FOOT MAGAZINE | | |
| 7. AUTHOR(s) | | 6. PERFORMING ORG. REPORT NUMBER |
| Frank J. Hanzel Charles L. Berkey | | |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS | | 8. CONTRACT OR GRANT NUMBER(s) |
| Naval Surface Weapons Center Dahlgren Laboratory Dahlgren, Va. 22448 | | |
| 11. CONTROLLING OFFICE NAME AND ADDRESS | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| | | |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | | 12. REPORT DATE |
| | | Sept 1974 |
| | | 13. NUMBER OF PAGES |
| | | |
| | | 15. SECURITY CLASS. (of this report) |
| | | UNCLASSIFIED |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |
| | | |
| 16. DISTRIBUTION STATEMENT (of this Report) | | |
| Distribution limited to U.S. Gov't agencies only; Test and Evaluation; (SEPT 1974). Other requests for this document must be referred to Commander, Naval Surface Weapons Center, Dahlgren Laboratory, Dahlgren, Virginia 22448 | | |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) | | |
| | | |
| 18. SUPPLEMENTARY NOTES | | |
| | | |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) | | |
| | | |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) | | |
| SIDEWINDER MK 17 MOD 5 motors were ignited in two tests in an instrumented, 15,300 cubic-foot missile magazine under conditions which would simulate accidental ignitions of this motor under shipboard service conditions. The results established a detailed temperature and pressure profile in the magazine, and the thermal characteristics of inert, instrumented ZUN1 motors located in the magazine. | | |

DD FORM 1473
1 JAN 73EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Temperatures and pressures within the magazine reached peaks of 570°F and 5.1 psi, respectively, external and internal temperatures for the instrumented ZUNI motors peaked at 175°F and 100°F, respectively, which would not have caused cook-off had the motors been "live".

Environmental conditions in the magazine were not as severe as expected.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)